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TALC DEPOSITS OF STEATITE GRADE

INYO COUNTY, CALIFORNIA

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Prepared in Cooperation with the United States Geological Survey

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ABSTRACT

Steatite is exceptionally pure talc suitable for the manufacture of high-frequency radio insulators and for other exacting uses. It was a critical mineral during World War II. At the beginning of the war there was a single major domestic source, the Talc City mine, Inyo County, California. During the war talc from several other mines in California, Nevada, New Mexico, and Montana was utilized as steatite.

California continues to lead in the production of domestic steatite. All known steatite deposits in the State are in Inyo County. Talc of near-steatite quality occurs in other California counties, but has not proved acceptable to manufacturers of high-frequency insulators.

At the end of 1942 the known steatite reserves of Inyo County were estimated to be only 86,700 tons and the rate of production was computed to be equivalent to about 15,000 tons annually. Production slackened somewhat, and exploration and development since 1942 have revealed substantial tonnages of steatite which tend to maintain known reserves. The supply of Inyo County steatite is seriously limited, however.

Many of the Inyo County steatite deposits are geologically similar in some respects. Limestone is the most prevalent original rock. Massive dolomite of hydrothermal origin has replaced the limestone in areas measuring hundreds or thousands of feet in breadth. Unaltered remnants of limestone occur as "islands" in the tracts of massive dolomite. Silica rock resembling quartzite also forms islands in some of the massive dolomite. The talc deposits are commonly ragged, elongated, steeply-dipping bodies in massive dolomite or silica rock. They are of hydrothermal origin and are generally localized at lithologic contacts along which some differential movement has occurred, but some are localized by faults or minor shears within a single rock type. There are various host rocks.

Steatite ore bodies have been formed by the replacement of massive dolomite at Talc City, East End, Victory, Trinity, and White Swan mines; steatite ore bodies have resulted from the replacement of silica rock at Alliance, Irish, Frisco, Viking, and White

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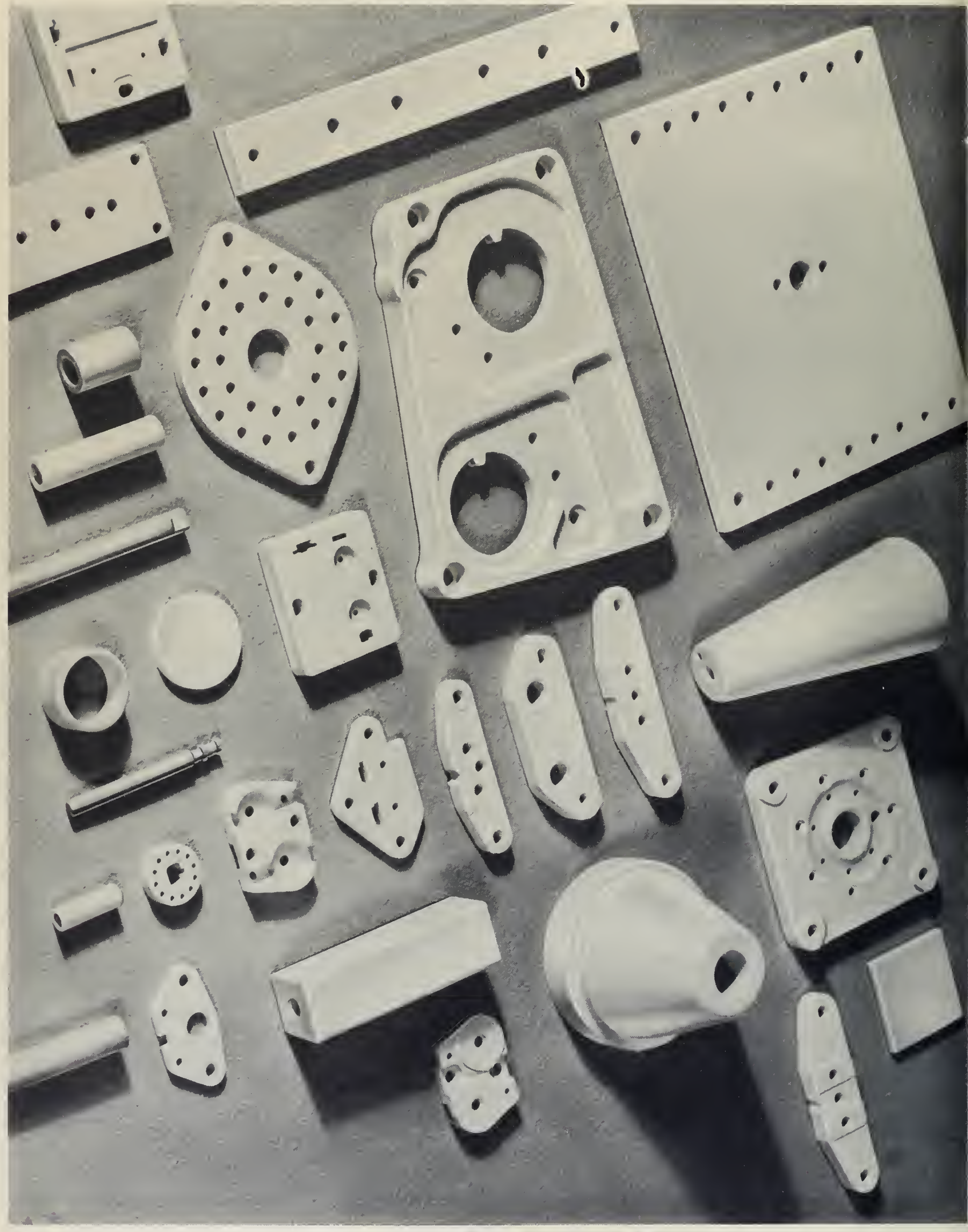


FIGURE 1. Ceramic insulators made principally of steatite.

Iountain mines; steatite has replaced limestone at the Blue Stone ind Willow Creek mines; talc of near-steatite quality has replaced ranite at the White Eagle mine. Therefore, the steatizing solutions re not strictly selective in their action, although they show a prefer- nce for certain host rocks.

INTRODUCTION

"Steatite" in a mineralogical sense means soapstone r massive talc, but in present-day industry the word has different connotation. In commercial usage and in this eport, steatite means exceptionally pure talc [1] suitable or use as the principal ingredient in certain ceramic odies. Because these bodies are widely employed for igh-frequency insulators in radios and other military nd civilian equipment [2] (see fig. 1), steatite was included n the list of critical minerals during World War II.

Although steatite has never been adequately defined, t is generally understood to mean certain varieties of alc containing less than 1.5 percent CaO, less than 1.5 ercent Fe_2O_3, and minute amounts only of other chemi- al and mineral impurities. The commercial designation teatite is also dependent upon favorable firing proper- ies, and satisfactory electrical and physical character- istics of the final product.[3] Commercial acceptance is generally contingent, moreover, upon adequate supplies of uniform material, as the dies of the manufacturer are designed for raw material of constant shrinkage prop- erties.

Lava-grade block talc is a variety of steatite distinguished by its suitability for machining. It must be free of flaws and must not crack during firing. Formerly, lava-grade block talc was the only type of steatite used for insulators. Now, however, it is employed only in relatively small quantities for spacers in radar vacuum tubes and for other specialized purposes. Since the discovery in the early 1920's that pulverized talc could be used for making insulators, most steatite has been ground before firing. It is mixed with a binder, and pressed or extruded into the required shapes. Because of these technical advances, the definition of steatite does not stipulate blocky characteristics.

During World War II emphasis was placed upon the importance of steatite in the manufacture of radio insulators, and consumption of the raw material was restricted to such purposes. However, steatite is equal, or superior, to ordinary talcs for many less exacting uses. Therefore, it has been used during peacetime in the manufacture of high-quality paper, cosmetics, insulating cores for electric stoves, gas burner tips, and many other items. The consumption of steatite for certain nonessential purposes constitutes a problem in conservation.

Foreign countries, including France, Italy, and Manchuria, provided much of the steatite-grade talc used in the United States prior to World War I, when California became an important producer. During the years between World War I and World War II, California was almost the only domestic source for talc used in radio ceramics; when the United States entered World War II, ceramic manufacturers depended upon two California mines for virtually all their new raw steatite. In the first part of 1943, California steatite was mined at a rate equivalent to 15,300 tons per year. California now ranks first among the states in steatite production.

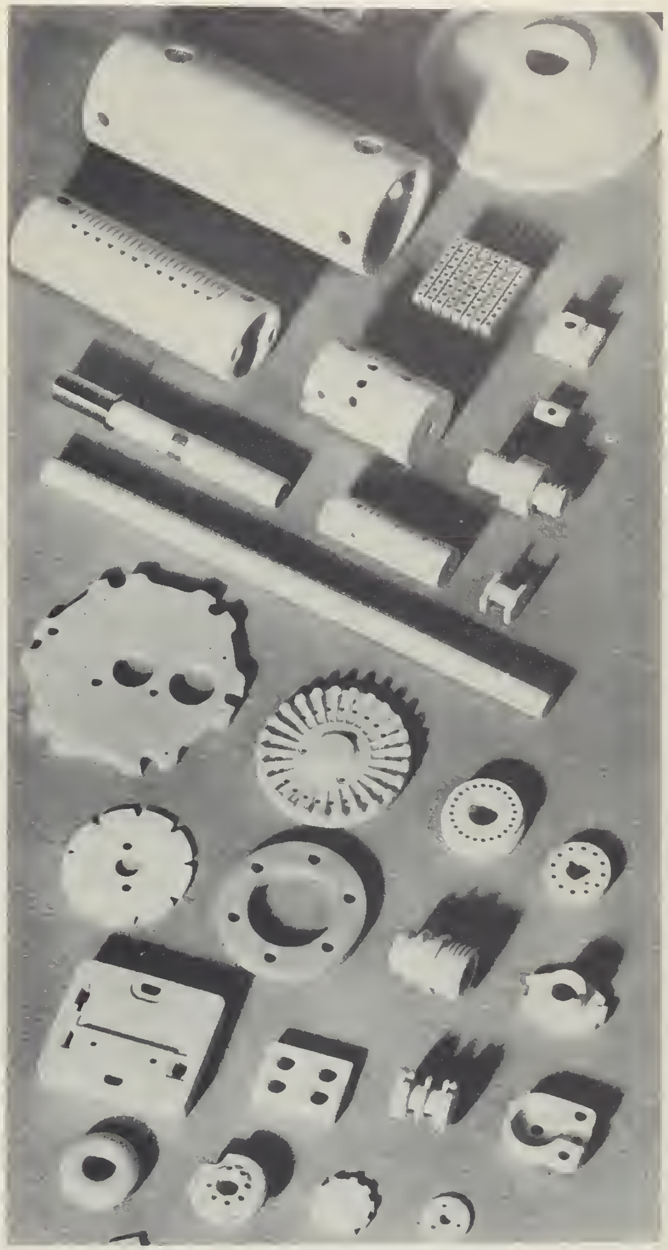


FIGURE 2. Miscellaneous ceramic articles made principally of steatite.

Other western states began to produce steatite during and after the war. In 1946, California yielded 9,600 tons [4]; Nevada was in second place with 6,000 tons; Montana was third, and New Mexico reported some production.

[1] A good discussion of talc in general, with references, will be found in Engel, A. E. J., Talc and ground soapstone *in* Industrial minerals and rocks: Am. Inst. Min. Met. Eng., pp. 1018-1041, 1949.

[2] Anon., Talc: Ceramic Industry, vol. 32, pp. 38-40, 1949. This gives other references on the ceramic uses of talc.

[3] A Conservation Order of the War Production Board (M-239, March 28, 1944, as amended, p. 1) imperfectly defines steatite as follows: " 'steatite talc' means naturally occurring magnesium silicate both crude and beneficated, suitable for use in the manufacture of electrical insulators and containing not to exceed one and one-half percent (1½%) lime (CaO), not to exceed one and one-half percent (1½%) ferric oxide (Fe_2O_3), and not to exceed four percent (4%) alumina (Al_2O_3)."

[4] For the same year, the California output of talc of all grades was about 75,000 tons.

It must be emphasized that the foregoing data apply only to talc of steatite grade. New York, at present, outranks all other states with regard to non-steatite talc production.

In 1941 the Planning Branch of the U. S. Army pointed out that steatite insulators were required for all military radios, and that the domestic production of raw steatite came largely from a single source, the Talc City mine in California. At the request of Brigadier General Hines, the U. S. Geological Survey and the U. S. Bureau of Mines undertook a talc investigation which was carried on during 1942 and intermittently thereafter.

The U. S. Bureau of Mines made partial analyses and beneficiation tests of talc samples at the Southern Experiment Station, Tuscaloosa, Alabama, and conducted some ceramic and electrical tests at the Electrotechnical Laboratory, Norris, Tennessee.[5] The Bureau of Mines also made field examinations of some talc deposits, particularly in the eastern and southern states. Only a small fraction of the information obtained by the Bureau of Mines is included in this paper, which is chiefly concerned with the work of the Geological Survey.

The Geological Survey mapped or described all known domestic steatite deposits and many deposits of possible steatite grade, most of which are in the western states. The work was largely done during 1942 under the direction of G. R. Mansfield, geologist in charge of the Section of Areal and Nonmetalliferous Geology. A preliminary examination of the known steatite sources in Inyo County, California, was made by D. M. Lemmon. The subsequent field work was done by L. A. Wright and B. M. Page.

In California 32 talc mines and prospects were visited. Those which were known to be producing steatite or probable steatite were mapped geologically, both underground and on the surface. "Ore" which had been approved by steatite consumers was not sampled by the Survey, but certain doubtful or low-grade talcs in the proved steatite mines were sampled. The U. S. Bureau of Mines tested the samples of substandard talcs to find out whether or not beneficiation was possible. The mines and prospects in talc deposits of unproved quality were examined hurriedly.

Acknowledgments

The U. S. Geological Survey's talc project received invaluable aid from any persons and organizations. Lauren A. Wright did half the field work leading to this report. Several other members of the Survey, including G. R. Mansfield and D. M. Lemmon, helped in every possible way. The Geological Survey is greatly indebted to the Bureau of Mines, particularly to T. A. Klinefelter and Richard W. Smith of the Southern Experiment Station. Essential information was contributed by numerous mine operators and other interested parties, including Franklin Booth, Otis Booth, Henry Mulryan, P. E. Thomas, W. K. Skeoch, W. A. Reid, James McNeil, Frank Canal, Roy Conlon, Marlyn and W. E. MacBoyle, William Bonham, Joseph Ganim, Watson Rich, Wright Huntley, and many others. The thin sections used in this study were expertly made by Alexander Tihonravov.

[5] Klinefelter, T. A., Speil, S., and Gottlieb, S., A survey of the suitability of domestic talcs for high-frequency insulators: U. S. Bur. Mines Rept. Inv. 3804, 1945.

Location

Inyo County, in east central California, is the outstanding steatite province in the nation, in terms of past and present production. Most known California steatite is in or near the Inyo Range. A particularly important part of the area, embracing the notable Talc City mine and several other deposits, is the upland between Keeler and Darwin, just south of the Inyo Range proper.

All the proved steatite of California is in Inyo County, but elsewhere in the state a few talc deposits are possibly of steatite grade. For instance, some of the talc in the Ganim mine, Shasta County, has yielded favorable analyses, but a large part of the material does not satisfy steatite requirements.[6]

Non-steatite talc deposits, such as the tremolitic talc deposits of the Silver Lake and Death Valley-Tecopa regions of California, are more numerous and much larger than the steatite talc deposits, and generally have a different geologic setting. These enormous talc resources are most prominent in San Bernardino County and in eastern Inyo County,[7] and are more widely known than the steatite ores farther west. Figure 3 shows the location of most of the steatite deposits in California examined by the author. The locations of many California talc deposits are also given in "Mineral Resources for 1922",[8] but no distinction is made between steatite and non-steatite.

Topography and Accessibility

The Inyo Range is a high north-south fault block of the Basin and Range province. It is bordered on the west by Owens Valley, and is partly bordered on the east by Saline Valley. The latter is an uninhabited desert basin, but Owens Valley has several towns, including Olancha, Keeler, Lone Pine, Independence, Bigpine, and Bishop.

The steatite deposits in the Inyo Range and adjacent uplands range in altitude from about 2,500 to 7,000 feet above sea level. The Talc City mine and nearby talc properties are in a hilly terrain readily entered by road; they are less than 3 miles from the paved highway between Keeler and Death Valley. Many of the other steatite localities are not so easily reached, however, being more remotely situated in steep canyons on rugged, precipitous slopes. These properties are accessible by rough, steep, winding roads at best. In the Inyo Range, three aerial tramways have been built to deposits of silver, salt, and talc, respectively.

Most of the steatite produced in Inyo County is sent by trucks to a narrow-gauge branch of the Southern Pacific Railroad. This branch line, which is in Owens Valley along the western foot of the Inyo Range terminates southward at Keeler; at Owenyo (16 miles northwest of Keeler) it is met by the Southern Pacific standard-gauge track leading to Mojave and Los Angeles.

Climate, Water, and Timber

The Inyo Range is in a desert region which is hot in summer and cold in winter. Snow impedes the winter operation of the White Mountain mine, but most of the other mines are below the zone of heavy snowfall. The

[6] (Page, B. M., and Wright, L. A.), Talc in the Ganim mine, Shasta County, California; U. S. Geol. Survey, Strategic Minerals Investigation, Prelim. Maps, 1943.

[7] Wright, L. A., California talcs: Min. Eng., vol. 187, pp. 122-128, 1950.

Diller, J. S., Mineral resources for 1913: U. S. Geol. Survey, pp. 153, 155, 157-160, 1914.

[8] Sampson, E., Mineral resources for 1922: U. S. Geol. Survey, pp. 81-83, 1923.

region is generally dry, and water for several of the mines is hauled from Owens Valley. There is no timber except at the properties which are over 5,000 feet above sea level. Juniper and piñon, but no large trees, grow in some of the higher areas.

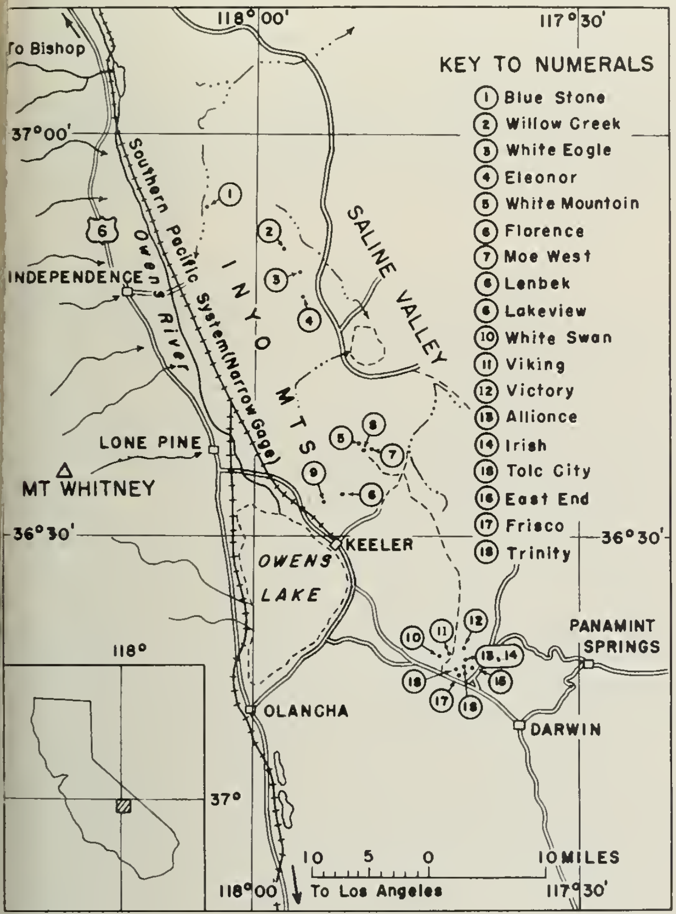


FIGURE 3. Index map showing location of California steatite and near-steatite deposits on record in 1942. All are in Inyo County. Inset gives location of area in outline map of state.

GEOLOGY

A reconnaissance of the Inyo Range is described by Knopf and Kirk,[9] and the reader is referred to their paper for a general discussion of part of the area. However, the talc deposits are not mentioned by Knopf and Kirk, and the major deposits including those of the Talc City mine (see fig. 5) lie to the southeast of the terrain covered in the reconnaissance.

Most of the steatite deposits are associated with three kinds of rock: limestone, silica rock, and massive dolomite. The limestone, Paleozoic (?) in age, is the principal original rock. The "silica rock" of this report is a quartzite-like material; it may be recrystallized sandstone, or it may be a product of hydrothermal alteration. The massive dolomite is definitely an alteration product derived mainly from limestone.

The typical areal distribution of the three characteristic rocks is as follows (see fig. 5): The limestone occurs chiefly as extensive tracts, within which are large areas of massive dolomite. The massive dolomite areas contain "islands" of unaltered limestone, islands of silica rock, and talc deposits. The massive dolomite is the most prevalent rock in the immediate vicinity of the mines.

[9] Knopf, Adolph, A geologic reconnaissance of the Inyo Range and the eastern slope of the Sierra Nevada, California; with a section by Kirk, Edwin, The stratigraphy of the Inyo Range: U. S. Geol. Survey, Prof. Paper 110, 130 pp., 1918.

The majority of the steatite deposits are lenses or irregular masses in dolomite or silica rock. Much of the steatite is along contacts between two rock types, but some is localized by fractures within a single rock unit.

Exceptions to the above generalities include deposits in which massive dolomite is lacking, or in which silica rock is absent. Some steatite is associated with various rocks that are not present at the more typical deposits.

Granitic rocks are exposed within half a mile to 2 miles of most of the steatite mines, and one deposit of uncertain quality is largely within a granitic host rock.

Lithology

The rocks of the Inyo County steatite areas are uncorrelated units which show some resemblances from mine to mine. The stratigraphy is not yet understood; the age of the sedimentary formations is not known, some of the rocks are secondary products, and other rocks (e.g., the silica rock) may or may not have a stratigraphic position. For these reasons, it is impossible at present to give a columnar section for the various talc deposits. The lithologic features that are possessed in common are described here, and local characteristics and additional rock varieties will be treated in the descriptions of individual mines.

Limestone. The oldest rocks in the immediate vicinity of the steatite mines are limestone. The age is probably Paleozoic, but positive evidence is lacking. Undoubtedly more than one formation is represented; however, the strata have not been assigned to formational units.

Expanses of limestone, extending partly around the periphery of the principal mine areas, form the background of most of the talc deposits (see fig. 5). Limestone also occurs as remnants within the mine areas, where much of it has been altered to massive dolomite. The several lithologic varieties may be grouped into two main types.

The most prevalent type of limestone, exemplified at the Talc City mine, is a well-stratified gray rock with subordinate thin white layers a fraction of an inch thick. Locally it is slightly fissile, but is not highly jointed. During weathering it develops smooth outcrop surfaces. This rock is easily scratched by steel, and effervesces vigorously in cold, dilute hydrochloric acid. A few layers contain poorly-defined crinoid (?) fragments, and others contain minute bits of carbonized plant remains.

A second, less plentiful, type of limestone is dense, relatively hard, siliceous, and contains dolomitic beds. This variety is black, weathering to a pale-gray or tan-gray color, and it commonly contains flint or siliceous streaks with coarser texture than flint. It is distinctly stratified in beds 3 inches to 3 feet thick, but is not thinly laminated or platy except where altered. It is scratched less easily than pure limestone, and effervesces less readily in cold, dilute hydrochloric acid. The "stratified dolomite and limestone" of the Talc City mine and the "flinty dolomitic limestone" of the White Mountain mine are examples of this type of rock.

Silica Rock. A silica rock, consisting of quartz and closely resembling quartzite, is prominent in most of the Inyo County steatite areas. It forms strong, massive outcrops. The silica rock is unstratified, and contains no fossils. It is gray where fresh, but in many places it weathers dark brown. The brown color is helpful in distinguishing the rock from the massive dolomite which commonly surrounds it. The silica rock cannot be scratched by steel, and when it is struck by a hammer sparks sometimes are produced.

The silica rock generally occurs in isolated, discontinuous patches of peculiar shapes, within areas of massive dolomite (fig. 5). Lack of areal continuity and lack of systematic structural arrangement are the most puzzling features of the rock.

Two hypotheses regarding the silica rock are as follows: (1) At one time it may have been sandstone, which has since been partly recrystallized. If so, it should properly be termed quartzite. Or (2) it may be a product of hydrothermal alteration of dolomite.

The first hypothesis is supported by the fact that ordinary quartzites do occur in the Inyo Range; an important example is the Eureka quartzite (Ordovician), which serves as a marker bed in the range.[10] Some steatite deposits of the region are clearly associated with ordinary quartzite, as at the Blue Stone mine (fig. 3). Possibly the silica rock of most of the steatite deposits is also quartzite. This possibility is favored by the texture of some, but not all. of the silica rock; locally the quartz grains are well-rounded, as in many sandstones.

The main objections to the theory that the silica rock is quartzite are occasioned by the distribution. The rock must have been a stratiform sedimentary formation at one time, if it is quartzite, but obviously it is no longer stratiform in its typical occurrences. The separate patches of silica rock cannot be explained as the result of erosion of a formerly continuous stratum, because the distribution is as erratic at depth as it is on the surface of the ground. The field relations cannot be interpreted purely as a result of faulting, as the requisite faults for such a theory do not exist. If the silica rock actually represents former sandstone beds, there are two possible explanations for its present lack of stratiform continuity: (1) parts of the sandstone may have disappeared by conversion into dolomite; (2) the sand of the original sandstone beds may have been gathered into separate masses by some process which produced the present scattered discontinuous bodies of silica rock surrounded by unbroken dolomite. According to this view, the gathering-up of the sand, forming isolated masses, was accomplished before the dolomitization of the bordering rocks, as the massive dolomite shows no corresponding deformation.

The hypothesis of hydrothermal origin readily explains the field relations of the silica rock. According to this hypothesis, hot waters rose upward through the dolomite and altered it to silica rock. This occurred only where fractures, temperature, pressure, or chemical conditions were appropriate; therefore, the silica rock was produced not as a continuous mass, but as a number of separate bodies. The hydrothermal interpretation is favored by the lack of bedding in the silica rock, and by the virtual absence of minerals other than quartz; there are practically no grains of feldspar on ferromagnesian minerals. The texture of some of the rock is in accord with the hydrothermal hypothesis, as some specimens show irregularly shaped grains closely fitted together along intricate boundaries. This is inconclusive evidence, however.

Silica rock is second only to massive dolomite as a host rock for steatite. Steatite-bearing silica rock gen erally occurs as "islands" in massive dolomite. This is the relationship at the Alliance mine, for example. However, some of the talc at the White Mountain mine is in silica rock that is 50 to 100 feet outside the dolomite area.

Massive Dolomite. Limestone has been altered to massive dolomite in the immediate proximity of the talc deposits.

The color of the dolomite ranges from white to gray to black, probably because carbonaceous material in varying amounts is retained from the original limestone. Outcrops of massive dolomite are extensive and prominent, and commonly have harsh, hackly surfaces. The rock surfaces are criss-crossed by small grooves which look as though they had been made by the dull edge of a knife. The grooves are spaced approximately ½ to 1 inch apart, and are caused by the solution of thin calcite seams that occupy joints in the dolomite.

The massive dolomite is devoid of bedding, unlike the limestone of the district, and it contains no remnants of fossils. It is tougher and harder than the limestone, but may be scratched by steel. The dolomite must be scratched or pulverized before it will effervesce in cold, dilute hydrochloric acid; however, the numerous calcite seams effervesce more readily and may be misleading.

The massive dolomite varies in grain size. In many specimens the grains are barely discernible with a hand lens. In other specimens, they are easily seen by the naked eye, and the rock is best described as a dolomitic marble.

The field relations of the massive dolomite point to a hydrothermal derivation from limestone. The dolomite areas are partly bordered by unaltered limestone, and the limestone beds locally terminate against the dolomite rather abruptly. The relationships cannot be explained by faulting, as the limestone is not separated from the dolomite by gouge, breccia, slickensided surfaces, or other evidence of faults. In places the dolomite has invaded limestone in tongues and cross-cutting bands, obliterating the bedding. Within the dolomite areas, islandlike remnants of unaltered limestone are found. The dolomitized zones are unrelated to topography, open fissures, or indications of weathering; therefore, they cannot be ascribed to the action of meteoric waters.

Massive dolomite is pre-eminent as a host rock for steatite. Most of the deposits are in, or adjacent to, massive dolomite. This is illustrated by 12 of the 15 steatite properties examined in Inyo County. Some of the ore bodies are completely enveloped by dolomite, as at the Trinity mine, but some are within islandlike patches of other rock isolated within the massive dolomite; the steatite-bearing "islands" consist of silica rock, stratified dolomite, or limestone. A few deposits are just outside the periphery of dolomitized areas.

Other Rocks. Slate and thin-bedded sandstone, in minor amounts, are associated with the limestone of the Irish lease (fig. 3), and a small thickness of hornfels occurs southwest of the Talc City mine (fig. 5).

[10] Merriam, Charles W., oral communication.

FIGURE 4. View of Talc City mine from the southeast. GH—west glory hole; HF—headframe of main shaft; BA—B level adit.

Granitic igneous rocks are exposed in the vicinity of some of the talc deposits. Megascopically they appear to range from granite to granodiorite or quartz monzonite. Some of the granitic areas near the talc mines are located as follows: one is between Keeler and Darwin, just south of the Talc City mine; another is on the east side of the Inyo Range just north of the White Mountain talc mine; and a very large granitic area, shown by Knopf [11] between Independence and Saline Valley, extends to the White Eagle and Willow Creek talc mines near the north end of Saline Valley (fig. 3).

The relations between the plutonic rocks and the other petrologic units are only partly understood, but Paleozoic (?) limestone and hornfels are intruded in some places (fig. 5). The granitic rocks of the Inyo Range are probably outlying extensions of the plutonic complex of the Sierra Nevada. If this is so, their age is probably late Jurassic or early Cretaceous.

Dike rocks ranging from basalt or diabase to light-colored felsite occur near the Frisco, Talc City, and White Mountain mines. The dikes cut across Paleozoic (?) limestone and the granitic rocks, and small altered dikes have been found in the massive dolomite.

Geologic Structure

Folds. The unaltered rocks (chiefly limestone) in the vicinity of the steatite mines are generally folded. For example, north of the Talc City mine there is a pair of tightly compressed synclines, south of the mine there are several isoclinal folds, and to the east and west of the mine the beds dip from 50° to 90° (fig. 5). The rocks of some of the steatite areas show no fold axes, but nevertheless dip moderately to steeply, and probably represent the limbs of former folds.

Some folds in limestone have been practically obliterated by dolomitization, the massive dolomite retaining only a few remnants of stratified limestone. The orientation of the unreplaced strata indicates the probable pre-dolomite structure; this is illustrated at the Talc City mine.

The major folding in the region occurred before the emplacement of the granitic intrusions, according to Knopf,[12] and is probably late Jurassic in age. It preceded, and may have facilitated, the dolomitization.

Faults. Faults of several ages have been observed and inferred. They may be classified as: (1) pre-dolomite, (2) post-dolomite and pre-steatite, (3) post-steatite.

Pre-dolomite faults are not positively established, but are indicated by incomplete evidence. For example, at the Talc City mine early faulting is suggested by the apparent repetition of lithologic units that occur as unaltered remnants surrounded by massive dolomite. No fault is visible, but perhaps dolomitization obliterated it, leaving unaltered parts of the hanging-wall block and the footwall block isolated in the expanse of dolomite. Any faults which existed prior to the hydrothermal action doubtless facilitated dolomitization.

Post-dolomite and pre-steatite faults are important, as they are occupied and bordered by talc in some places. They are probably faults of small to moderate displacement (1 to 100 feet?) for the most part, except at the White Mountain mine, where the displacement may have been several hundred feet.

Post-steatite faulting on a minor scale is shown by the sheared condition of most of the talc. This sheared condition in many places resulted from renewed movement on pre-steatite faults. An exceptional post-steatite fault of great displacement (thousands of feet?) forms one boundary of the productive steatite area at the White Mountain mine, but most of the other mine areas have not been so strongly affected by post-steatite movements.

Structural Relations of Ore Deposits.[13] Structural controls are visible or may be surmised in many steatite deposits. Contacts between rock units have favored the development of some ore bodies, as at the Talc City mine, where much of the steatite occurs along the boundaries between massive dolomite and stratified dolomite or limestone. At the Alliance mine the main ore body is at the juncture between massive dolomite and silica rock. The contacts between lithologic units were probably incipient planes of weakness before the talc was deposited. Minor differential movement in the rocks was concentrated at the contacts of adjoining lithologic units.

Faults are likewise effective as structural controls. Some of the steatite at the White Mountain mine occurs along a fault between dolomitic limestone and silica rock. Some minor deposits of the Talc City area are wholly enclosed in massive dolomite, which appears to have been sheared or faulted on a small scale prior to the deposition of the talc.

In some localities, such as the Victory mine, no structural control of the ore bodies is apparent.

Comparative Features of Individual Deposits

The following table indicates some of the similarities and differences between the various steatite deposits described in this report. One or two near-steatite deposits are included.

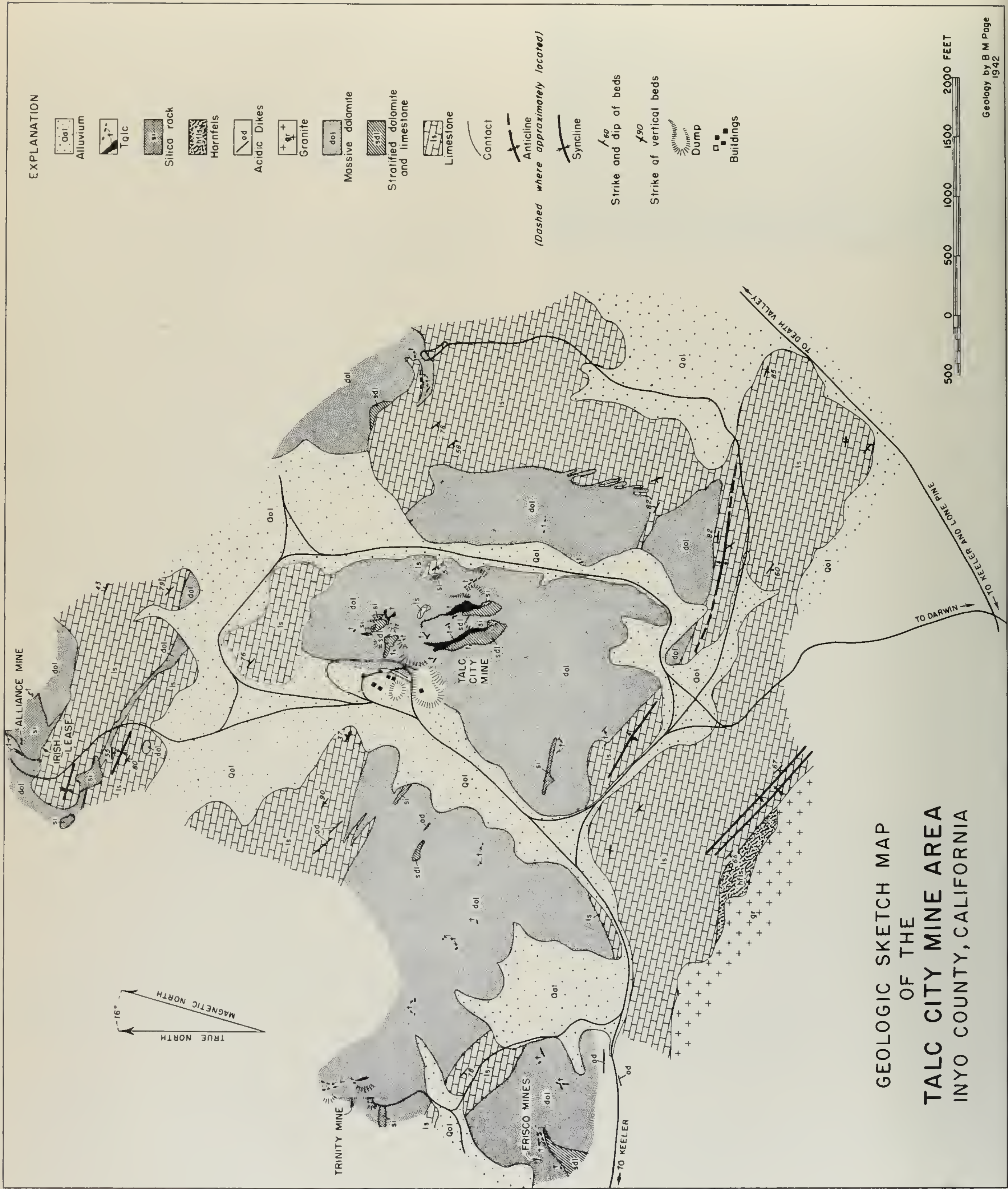
Physical Characteristics

It is generally impossible to distinguish steatite from other grades of talc at sight, but most steatite has certain common fractures. It is often possible to judge by the outward appearance whether or not a material merits thorough testing. For final identification, a talc suspected of being steatite must be laboratory tested; analyses

[11] Knopf, Adolph, A geologic reconnaissance of the Inyo Range and the eastern slope of the Sierra Nevada, California: U. S. Geol. Survey Prof. Paper 110, pl. 1, 1918.

[12] Knopf, Adolph, A geological reconnaissance of the Inyo Range and the eastern slope of the Sierra Nevada, California: U. S. Geol. Survey Prof. Paper 110, p. 9, 1918.

[13] The term "ore", which in a strict sense applies to metallic deposits, is used loosely in this report to designate talc of steatite quality. In this paper "ore deposit" or "ore body" means a minable mass of steatite. This usage, although debatable, is well established in the steatite mines.



GEOLOGIC SKETCH MAP
OF THE
TALC CITY MINE AREA
INYO COUNTY, CALIFORNIA
EXPLANATION
Alluvium
Talc
Silica rock
Hornfels
Acidic Dikes
Granite
Massive dolomite
Stratified dolomite and limestone
Limestone
Contact
Anticline
(Dashed where approximately located)
Syncline
Strike and dip of beds
Strike of vertical beds
Dump
Buildings
500 0 500 1000 1500 2000 FEET
Geology by B M Page 1942
TRUE NORTH
MAGNETIC NORTH
16°
ALLIANCE MINE
IRISH LEASE
TALC CITY MINE
TRINITY MINE
FRISCO MINES
TO KEELER
TO DARWIN
TO KEELER AND LONE PINE
TO DEATH VALLEY

Name of deposit	*Principal country rock*	*Rock replaced by talc*	*Structures controlling ore bodies*
Talc City	Massive dolomite, silica rock, limestone, stratified dolomite and limestone	Massive dolomite	Contacts and shears
East End	Massive dolomite, limestone	Massive dolomite	Contact
Victory	Massive dolomite	Massive dolomite	None visible
Trinity	Massive dolomite, silica rock	Massive dolomite	Minor fractures?
White Swan	Massive dolomite	Massive dolomite	Minor shears?
Alliance	Massive dolomite, silica rock	Silica rock	Contacts and shears
Irish	Massive dolomite, silica rock, limestone, slate	Silica rock	Contacts and shears
Frisco	Massive dolomite, silica rock, limestone, felsite dikes	Silica rock	Contacts
Viking	Massive dolomite, silica rock	Silica rock	Contacts
White Mountain	Massive dolomite, silica rock, flinty dolomitic limestone, felsite dikes	Silica rock, etc.	Contacts, faults
Florence	Massive dolomite, flinty dolomitic limestone	Flinty dolomitic limestone, massive dolomite	Contacts, faults
Lakeview	Limestone or stratified dolomite, quartzite, diabase	Limestone or dolomite; quartzite also?	Contacts
Eleanor	Dolomitic marble, silica rock	Dolomitic marble, silica rock	Contacts
Blue Stone	Limestone, quartzite	Limestone	Contact(s)
Willow Creek	Limestone, granite	Limestone	Contact
White Eagle	Dolomitic marble, silica rock, granite	Granite, etc.	Contacts

for iron and calcium should be made, and preferably the aluminum content should also be determined. If the analysis shows more than 1.5 percent Fe_2O_3, 1.5 percent CaO, or 4 percent Al_2O_3, the talc is probably not steatite, although uniform specifications have not been adopted by manufacturers. Talc which gives satisfactory analyses should be submitted to steatite laboratories or manufacturers for ceramic, electrical, and physical tests before it can be classed definitely as steatite.[14]

Steatite shows the principal mineralogical properties of talc,[15] of which it is composed. It feels "soapy" to the touch, is so soft it may be scratched with the fingernail, and is easily cut by a knife. It is not affected by ordinary reagents.

Outcrops of steatite are fairly plentiful at the deposits, because talc is resistant to chemical weathering, but the outcrops are commonly eroded flush with the general level of the ground because of the softness of the mineral. Wide deposits of steatite may be topographically expressed by saddles or depressions.

In most exposures the talc is more closely fractured than the adjacent rocks. At some places it occurs as thick leaves or splinters standing on edge.

Where outcrops are lacking, steatite deposits are locally marked by the presence of talc fragments on the ground or in the soil; the pieces of talc, being chemically inert, tend to accumulate during the decomposition of the enclosing rocks.

Inyo County steatite is dense, fine-grained, and massive except for structures caused by shearing or crushing. It is not flaky, fibrous, or schistose with respect to mineral orientation, although in many deposits it is rudely platy or slickensided because of shearing. Locally the steatite is highly fractured or pulverized.

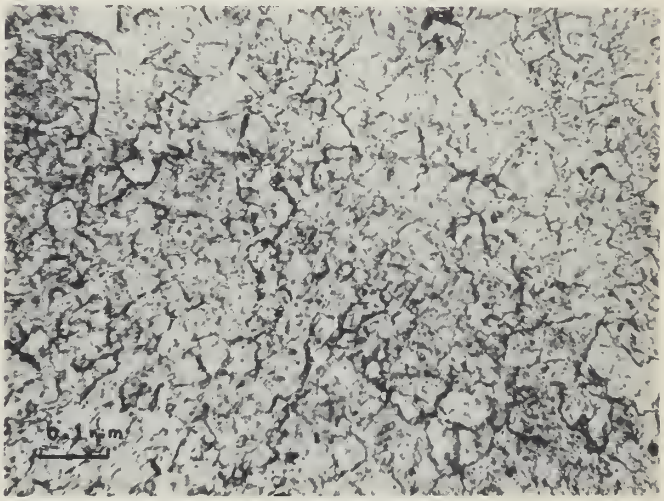


FIGURE 6. Photomicrograph of massive dolomite, Talc City mine. This is the host rock for most of the talc. Uncrossed nicols.

The common colors of Inyo County steatite are: pale gray green, pale green, pale tan green, pale tan, pale gray, dark gray, gray black, and white. The first-mentioned color is probably most prevalent. Some steatite is mottled; for example, gray and white mottled steatite occurs at the Alliance mine. Steatite is white or nearly white when powdered, regardless of the original color. However, raw steatite commonly is not as white as the non-steatite talcs of the Death Valley-Tecopa region and other localities.

Much steatite is translucent on thin edges, but this is by no means diagnostic. When scraped with the blade of a pocket knife steatite yields a powder that is soft and smooth to the touch, free of grit, and almost frictionless when rubbed between the fingers.

Some non-steatite talc shares the above characteristics and cannot be distinguished from steatite except by laboratory tests. On the other hand, certain kinds of

[14] A discussion of requirements and a description of tests by the U. S. Bureau of Mines is given by Klinefelter, T. A., Speil, S., and Gottlieb, S., A survey of the suitability of domestic talcs for high-frequency insulators: U. S. Bur. Mines Rept. Inv. 3804, 1945.

[15] For a complete description of the mineralogy of talc, see Dana, E. S., The system of mineralogy of James Dwight Dana, 6th ed., pp. 678-680, 1904.

Table 1

Sample *	SiO_2	Al_2O_3	TiO_2	Fe_2O_3	CaO	MgO	$KNaO$	*Ign. Loss*	*Total*
Theoretical	63.50	--	--	--	--	31.7	--	4.8	100
1-A	62.30	1.98	0.04	1.30	0.64	28.26	0.47	5.25	100.2
1-B	58.06	.85	--	1.21	.43	31.85	1.14	5.68	99.2
1-C	59.30	1.15	--	1.25	.08	32.08	.62	5.55	100.03
1-D	58.70	.68	--	1.28	.59	32.50	.22	5.98	99.94
1-E	60.05	.45	--	1.36	.09	32.10	.13	5.41	99.59

* The samples came from the following sources: 1-A, probably from Talc City mine; 1-B, Talc City mine; 1-C, White Mountain mine; 1-D, Lenbek mine; 1-E, Talc City mine.

talc contain megascopic impurities that obviously place them in a non-steatite grade. For example, fine needles of tremolite or actinolite are commonly seen with the aid of a hand lens; or calcite seams or abundant pyrite cubes may be visible. A very bright or very deep green color, not merely a pale shade, is also unfavorable, for it indicates a high chlorite content. Cubes or thick seams of limonite indicate a non-steatite grade, but thin films of limonite do not prevent a talc from being classed as steatite.

Inyo County steatite consists mainly of minute talc grains, 0.005 to 0.5 millimeter in length. These grains are anhedral crystals that are mutually unoriented or locally obscurely oriented (figs. 8 and 14).

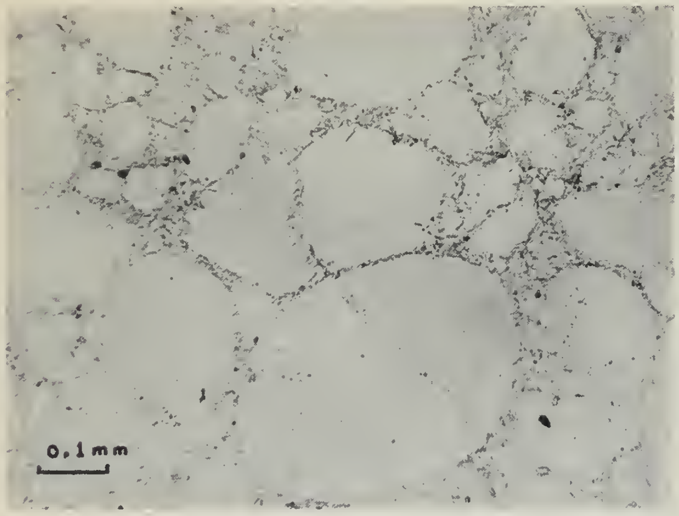


FIGURE 7. Photomicrograph of slightly altered silica rock. Some specimens have a sandy texture as above. The large grains are quartz; interstitial material is fine quartz and talc. Specimen from Frisco mine, near Talc City. Uncrossed nicols.

Sphene occurs sparingly in microscopic grains in some high-grade steatite, and is commonly accompanied by leucoxene. Smaller, unidentified mineral specks are also present. These minerals do not affect the quality of the ore.

Quartz, representing unaltered relicts of the parent silica rock, is found as microscopic grains in some of the acceptable steatite of the White Mountain and Alliance mines.

Pyrite, limonite cubes, heavy limonite coatings, and calcite grains and veinlets are undesirable impurities in some of the ore bodies. Talc containing an appreciable amount of these minerals is not of steatite grade and must be sorted out if it is mingled with the steatite. Calcite from veinlets tends to accumulate in the talc fines produced during blasting and handling of the ore, so the fines are seldom of steatite grade.

Partly steatized country rock forms boulders (impure lumps) in many ore bodies, and occurs around the margins of some deposits. The semi-talcose materials must be sorted out of the ore.

Manganese oxide dentrites and very thin, local limonite films are commonplace, and a pale-pink coating of unknown composition is found on steatite in some mines. These substances are generally not disadvantageous.

The compositions of five commercial steatitic talc samples from Inyo County, as given by Klinefelter, Speil, and Gottlieb,[16] are given in table 1. The analyses are compared with the theoretical composition of pure talc, $H_2Mg_3(SiO_3)_4$.

Origin

The original rock at the site of the steatite deposits was predominantly limestone, with a little stratified dolomite. Shale and sandstone were subordinate; some of the sandstone may now be represented by the silica rock, but this has not been proved.

The original rocks were folded—tightly in some areas—and were fractured and faulted. The structural deformation assisted the ensuing chemical alteration by affording fractures and inclined bedding planes along which solutions could move upward.

Rising hydrothermal solutions penetrated and altered the fractured formations. The solutions did not come from the granitic material now exposed near the talc mines, nor from the various dikes, but may have come from a deeper source related to the visible igneous rocks. The exposed plutonic rocks themselves have been hydrothermally altered in places, as the White Eagle mine, and so are clearly older than the alteration.

The hydrothermal reagents added magnesium to the original limestone, changing it into massive dolomite; the original stratified dolomite was likewise converted into massive dolomite. If the silica rock represents an original formation, it too must have been dolomitized locally; if it was not an original formation, it subsequently developed as a hydrothermal product in the various tracts of massive dolomite. Regardless of the origin, the massive dolomite contains islands of silica rock, unaltered limestone, and stratified dolomite. The hydrothermal changes healed most of the previously formed fractures, but a second epoch of fracturing occurred. The massive dolomite and adjacent rocks were sheared in places, and some slippage took place along the contacts between lithologic units.

Hot waters rose through the rocks, moving along the fractures and contacts, locally forming talc at a considerable depth below the ground surface. The talc was produced by the addition of water and silica to dolomite, and by the addition of water and magnesia to the silica rock. The steatization of the dolomite involved removal

[16] Klinefelter, T. A., Speil, S., and Gottlieb, S., op. cit., p. 11.

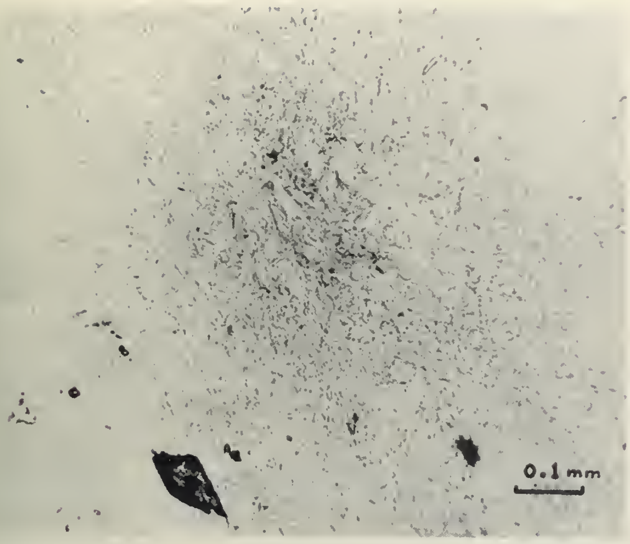


FIGURE 8. Photomicrograph of high-grade steatite from Talc City mine, showing texture. Large dark crystal near bottom of picture is sphene. Uncrossed nicols.

of calcium carbonate and carbon dioxide; and the steatization of the silica rock involved the removal of some silica to make room for the added constituents. Perhaps the hot waters obtained their content of magnesia and silica at various depths from dolomite and silica rock respectively, and redistributed these ingredients. The vigor of steatizing solutions is illustrated at the White Eagle mine, where granite and other host rocks have been altered to talc.[17] Evidently the solutions were not strictly selective, although they generally did show a preference for certain rock types such as massive dolomite and silica rock.

New or continued hydrothermal activity produced disseminated pyrite in some of the talc bodies, which are therefore not of steatite quality. More shearing also took place, and affected steatite and non-steatite talc in nearly all the deposits.

Size and Shape of Ore Bodies

The individual steatite deposits studied in Inyo County by the Geological Survey are very small to moderate in size, containing a few hundred to a few thousand tons, and are not nearly as large as many talc deposits of non-steatite quality. At the White Mountain mine a 10-year output of about 7,000 tons came from more than half a dozen separate ore bodies. The largest proved steatite deposits in California are at the Talc City mine, where about 135,000 tons came mainly from two ore bodies not depleted by the end of 1942.

In contrast to the above, some of the non-steatite talc of California occurs in deposits that contain from half a million to more than a million tons.

In general, most of the steatite ore bodies are elongated lenses or pods, as much as 600 feet in length and 50 feet in thickness. In detail they are highly irregular, with ragged outlines, frayed ends, offshoots, and locally gradational boundaries. Some steatite deposits contain many residual lumps of the original host rock, and grade into country rock full of talc seams and stringers. This is true at the White Mountain mine, Alliance mine, Talc City East Side ore body, and other deposits. In such bodies ore boundaries are not distinct.

Reserves

It is not advisable to publish reserves of the individual steatite properties. In some cases the owners are unwilling to have the data published, in other cases it is not known whether the talc is actually of steatite grade, and as a rule tonnage estimates of steatite deposits are grossly in error. The ore bodies are not geometrical, they cannot be projected with assurance beyond the available exposures, the older mine workings are caved and inaccessible, and in many properties development is scarcely kept ahead of mining. For these reasons accurate computations cannot be made.

The total steatite reserves of Inyo County were estimated by the writer at the end of 1942 as follows:

Measured	6,000 tons
Indicated (additional)	32,100
Inferred (additional)	48,600
Total	86,700 tons

These figures are, of course, inaccurate. They are extremely conservative, and merely denote the order of magnitude of the reserves. If the total of 86,700 tons had been correct, and if the rate of mining early in 1943 had been maintained, Inyo County steatite would have been exhausted in 1948. Fortunately, although some deposits were worked out during the war, the discovery of new ore bodies and the further development of old ones tended to maintain the reserves in much the same way that known domestic petroleum resources were maintained during the past several decades. However, steatite reserves are without doubt seriously limited.

MINES AND PROSPECTS

Talc City Mine

The Talc City mine is 19 miles by road southeast of Keeler and 6 miles northwest of Darwin, Inyo County, California, in a group of hills near the south end of the Inyo Range (figs. 3 and 5). Although the area is over 5,000 feet in altitude, it is arid and provides neither timber nor water for mining. There is no city at Talc City, despite the implication of the name. The mine was studied by the writer during a period of about 7 weeks in 1942.

Literature concerning the Talc City mine is very meager, although several brief references by Ladoo,[18] Sampson,[19] Tucker,[20] Waring and Huguenin,[21] and others appear in various books and journals. In the existing articles there is little more than a paragraph or two concerning the geology.

History and Production. The mine was first operated briefly about 1917 or 1918 under the name of Simonds talc mine. In 1918 it was purchased from the

[17] Wright, L. A., White Eagle talc deposit: an example of steatization of granite: (abst) Geol. Soc. America Bull., vol. 59, p. 1385, 1948.

[18] Ladoo, R. B., Talc and soapstone: U. S. Bur. Mines Bull. 213, pp. 111-117, 1923. Gives geological notes and flow sheet of mill. The mining company is referred to as the Inyo Talc Company.

[19] Sampson, E., U. S. Geological Survey, Mineral Resources for 1920, part II, pp. 203-204, 1923. Describes the talc and its technology.

[20] Tucker, W. B., California Div. Mines Rept. 17, pp. 300-301, 1920-21. Gives geological notes. Refers to mine as Simonds Talc mine.

Tucker, W. B., California Div. Mines Rept. 22, pp. 523-524, 1926. Two paragraphs on geology and development.

Tucker, W. B., and Sampson, R. J., California Div. Mines Rept. 34, pp. 492-495, 1938. Very brief statement.

[21] Waring, C. A., and Huguenin, E., California Div. Mines Rept. 15, pp 126-127, 1919. Report includes a reconnaissance geologic map of Inyo County.

California Talc Company by the Inyo Talc Company, which about 1922 became the Sierra Talc Company, the present owner of the mine and the largest producer of steatite in the nation. This concern has offices at 5509 Randolph Street, Los Angeles, and mills at Keeler and Los Angeles. Messrs. Franklin Booth, P. H. Booth, W. H. Booth, and Otis Booth have served as executive officers of the company, which is now owned by Mrs. Dorothy F. Dodds and Mr. Otis Booth. From 1918 to 1942, Mr. W. A. Reid was mine superintendent at Talc City; since 1942, Mr. James McNeil has held this position.

During the first few years of operation, the mine provided raw material for insulating cores of Hotpoint stoves. The cores were turned out of block talc, which was then fired. It was later found that ground talc could be used for the same products, preventing great waste, and all the ore is now ground. Much talc from this mine has been sold to the paper, rubber, and cosmetic industries. However, manufacturers of electrical insulators for radio and other equipment began to draw upon the Talc City production about 1936, and by 1942 virtually the entire output was used in high-grade electrical ceramics. The mine is the largest producer of steatite in the United States, and prior to World War II it was almost the sole domestic source of radio ceramic steatite.

The Talc City mine is said to have yielded 130,000 tons by early 1942. In 1941 the year's output was 5,800 tons, before the advent of the war-time steatite crisis. This crisis developed in mid-1942 and strained the capacity of the 20-year old mine to the limit. The Talc City mine produced approximately 70 percent to 80 percent of the nation's wartime steatite supply, an accomplishment which was only made possible by the adoption of more modern mining and engineering methods.

Mine Workings. The surface of the ground at the Talc City mine is characterized by large waste dumps (fig. 4), and by several subsidences where enormous gaping cracks furrow the surface of the ground.

Underground prospecting and development have been carried out exclusively by driving new workings, with no geologic mapping (prior to 1942) and with no core drilling. Geologic studies are now difficult because most of the older drifts and crosscuts are inaccessible.

Glory holes have been used during the past. The two largest are the "West" and the "Central"; in addition, there are the "Evening Star" and the "Ridge" glory holes (see pl. 1). These were tapped by several adits. More recent stoping and drifting at deeper levels beneath the glory holes has caused caving, and at present large portions of the ground surface and old underground workings are subsiding. In the upper parts of the caved ground a good deal of country rock has become mingled with the remnants of talc.

Since the days when talc was removed from glory holes through shallow adits, a maze of deeper drifts and cross-cuts has evolved, amounting to several miles of excavation. Not all of these workings are now accessible, but some are shown on the accompanying maps. There are two inclined shafts (pl. 1). One is on the west side of the principal hill, and the other on the east side. The west shaft starts at the A level and leads successively to the B level (63 feet lower than the collar), the 100-foot level, the C level (148 feet below the collar), and the D level (about 255 feet lower than the collar of the shaft). The shaft continues downward about 50 feet below the D level. The D level includes extensive workings, which were largely obstructed by caved talc and country rock at the time of the writer's field work (1942). According to Mr. Henry Mulryan, the D level was reopened and was yielding a substantial tonnage of steatite in 1946. Various intermediate levels (pl. 2) are not reached from the main shaft directly, but are connected by winzes or raises with the levels enumerated. In addition to the shaft, the nearby B level adit allows access to the workings (pls. 1 and 2).

The eastside shaft was abandoned for some time and was reopened in 1942. Drifts branch from it at depths of 58 feet and 94 feet below the collar. The east side workings are now connected with the main workings, but were separate in 1942.

In addition to the principal shafts and workings, about a dozen miscellaneous adits and shafts are connected imperfectly or not at all with the rest of the mine.

Operation. The operational history of the mine may be divided into two unequal parts, the first of which prevailed until the middle of 1942. The second part had just begun at the end of the writer's field work.

Before 1942, glory holes and underground caving involved great waste and danger. Occasionally ore was removed by simply taking out a section of lagging in a drift, allowing the adjacent broken talc to slide out onto the floor. More generally, the ore bodies were partly surrounded by workings driven in substantial country rock that was less likely to collapse; slanting chutes (raises) were then constructed into the nearby talc. The ore usually "mined itself" after the stopes reached an appreciable size, particularly after the ground had been disturbed by mining at deeper levels. During a period of months material was drawn from the chutes until broken country rock predominated over the talc fragments, or until dolomite "boulders" repeatedly clogged the chutes, halting the mining at that particular place. Premature stoping of ore near the D and C levels caused settling and shattering of overlying ore, and the partial collapse of drifts and stopes, many of which were not yet worked out. Afterwards, the talc remaining above the D and C levels was approached with difficulty.

Since the middle of 1942, during the later operations, an effort has been made to avoid caving. In the east side workings, square sets have been used, and the ore has been systematically removed.

The talc is trammed by hand from the stopes to buckets in the shafts. At the surface the ore is carefully hand-sorted, to eliminate visible calcite, dolomite, iron oxide, and excessively dark talc. The bulk of the lump talc is of steatite grade; the screenings, however, are higher in lime and are not used for steatite. The steatite is sent by truck 19 miles to the company's mill at Keeler, on a spur of the Southern Pacific Railroad. There the talc is ground in a Raymond mill with a whizzer air separator on top, then it passes through a cyclone. Tests for lime content, color, and fineness are made frequently during each mill run. The product, which is minus 200-mesh, is sacked for shipment, representative samples being retained for reference. All shipments of Talc City steatite are now ground talc, which is nearly pure white regardless of the color of the ore. Most of the product is sent by rail to manufacturers in the eastern states.

General Geology. The general geologic setting of the Talc City mine is shown on the sketch map (fig. 5), and the areal geology at the mine is shown in greater detail in plate 1.

The talc occurs as irregular, elongated bodies in an area of massive dolomite. The dolomite is almost surrounded by Paleozoic (?) limestone from which it was derived by hydrothermal alteration. Within the area of massive dolomite there are remnants of unaltered limestone, remnants of sedimentary stratified dolomite, and peculiar "islands" of a silica rock that resembles quartzite. A large mass of granitic rock that has intruded the limestone extends to within 3,000 feet of the mine.

Limestone (Paleozoic?) almost encircles the mine at a distance, and small patches of it are present near the workings (fig. 5 and pl. 1). Most of this limestone is gray, with a few thin white layers.

A stratified dolomite and limestone, different from that described above, occurs near the talc deposits (pl. 1). Its stratigraphic relationships are unknown, as it is principally found as isolated patches surrounded by massive dolomite. There is a marked difference between the character of the rock underground and the character on the surface. Surface exposures are distinguished by a tan to gray, smooth "buckskin" appearance, and by streaks and blebs of rusty, siliceous material that jut out in relief. Microscopic examination of the stratified dolomite and limestone collected from outcrops shows a sprinkling of coarse silt and fine sand, largely quartz, in a fine-grained carbonate matrix. Underground, the rock resembles shaly limestone and effervesces freely in cold, dilute acid. It is much softer, more fissile, and much less dolomitic than where exposed in surface outcrops. Probably these differences are caused by hydrothermal alteration near the ore bodies; most of the underground exposures of the stratified dolomite and limestone are in the immediate vicinity of the talc. Many of the workings within this type of rock have ragged, splintery, somewhat unstable backs and walls.

A silica rock closely resembling quartzite forms prominent outcrops at the Talc City mine. It characteristically occurs as isolated, discontinuous patches of peculiar shapes within massive dolomite (pl. 1), and its stratigraphic relationships are unknown.

Massive dolomite, utterly different from the stratified dolomite and limestone, is the predominant rock at the Talc City mine, and envelops or borders the talc deposits. It is a product of hydrothermal alteration, and was chiefly derived from limestone; it forms a tract 2,000 to 3,000 feet wide, and interrupts the expanse of gray limestone that constitutes the neighboring terrain (fig. 5). Within the area of massive dolomite are a few patches of unaltered gray limestone, tan stratified dolomite and limestone, and silica rock. The massive dolomite is devoid of stratification, has harsh, hackly outcrop surfaces, and ranges in color from pale gray to gray black. The single specimen tested by the writer was iron-free. The rock consists of subhedral to anhedral dolomite grains which, in most samples are 0.015 to 0.05 millimeter in diameter (fig. 6). The texture is coarser in the northeastern parts of the B level and C level of the mine, and these coarser facies are best described as dolomitic marble.

Diabase occurs in three or four very small dikes within the mine area. The dikes are from 2 inches to 2 feet thick, and are quite irregular, having filled branching joints in the massive dolomite. The word "diabase" is loosely applied here, as the original texture and minerals can only be surmised. Most of the rock is altered to a soft, fine-grained, dark-green material that disintegrates like shale in the open air. The best-exposed dike may be seen at the mouth of the A-level adit; near the main hoist house. This dike shows a relict flow structure and amygdules of quartz and calcite. The chief mineral is matted, fine chlorite, with talc and some kaolinite (?). There is a sprinkling of microscopic pyrite and limonite specks, and a few minute grains of sphene.

Outcrops of granitic rock (granodiorite?) are within 3,000 feet of the Talc City mine (fig. 5). This rock is exposed over a large area; it is cut by many basalt dikes. The granitic rock is bordered by hornfels in places, but elsewhere it has intruded limestone of the type that is found at the Talc City mine.

Geologic Structure. Folds, and perhaps a major fault, existed at the site of the Talc City deposits before the hydrothermal alteration of the rocks took place, but these structures have largely been effaced by dolomitization. The limestone that partly encircles the mine is strongly folded; the steeply dipping strata strike toward the mine, but are obliterated at the edge of the dolomitized area. Within the area of massive dolomite, the isolated patches of gray limestone and tan stratified dolomite are unaltered remnants of formerly continuous formations. The strata composing these remnants follow two trends (pl. 1). In the southern part of the mine area the strike of the remnants varies only a few degrees from north, but in the northern part the strike is west-northwest. The elongated talc bodies reflect imperfectly the strike of the neighboring stratified remnants, hence the talc also shows two dominant trends. These two trends were probably inherited from the strike of beds on two limbs of a fold, or on two sides of a fault.

The existence of a pre-dolomitization fault is also suggested by the repetition of lithologic units at the West ore body and the Central ore body (pl. 1). The arrangement and lithology of silica rock and stratified dolomite and limestone is almost identical in these two parallel ore bodies. Perhaps faulting of an inclined series of strata brought two formations into position side by side; dolomitization then obliterated the fault and engulfed all but the present remnants of the original formations.

Post-dolomitization faults of small to moderate displacement are present. Faulting has produced conspicuous effects within and along most of the larger talc bodies. Much of the talc was formed by replacement of wall rock along faults and subsequent mechanical movements have largely been concentrated in the ore bodies which are physically very weak, rather than in the strong country rock. Consequently countless, interlacing slickensided surfaces within some of the talc masses give the illusion that slippage has amounted to thousands of feet.

The movements that produced such pronounced effects in the talc yielded a few small, inconspicuous shears only in the massive dolomite. Most of the shears in dolomite are marked by an inch or two of gouge and breccia; some are bordered by silicified and sparsely pyritized zones. Some show solution effects of ground water, which has utilized them as channels, making some of the fissures as wide as 3 feet.

Some shears in the dolomite are not parallel with the ore bodies. Most of these are of little importance and are not traceable for more than 100 feet, but a possible exception is a fault (?) called the "Watercourse" which is said to terminate the Central ore body. The underground workings at the "Watercourse" were inaccessible at the time of the mapping.

Breccia zones poorly defined in comparison with the distinct shears, were noticed in the massive dolomite in a few places near the mine. They are mostly recemented with calcite. Some of them are linear, and others have no geometrical form, but none of them show fault surfaces. Large-scale phenomena of a different sort occur a quarter of a mile south of the mine, and also half a mile east of it. Here breccia in zones over 150 feet wide resembles a coarse mosaic, in which well-separated fragments of gray dolomite are bound together by white calcite. There are no distinct borders or fault surfaces along the zones.

The Talc. The Talc City ore is fine-grained, with no megascopic flakes, needles, or fibers. Some of it is highly sheared and slickensided, but some is less disturbed and is moderately massive when first opened up in the mine; upon exposure, incipient cracks open up and often produce a crude, irregular platy structure. The talc is softer than the fingernail but is quite brittle. Thin edges are translucent. Pale gray green, with or without a tinge of tan, is the typical color of the best steatite but some of the talc is dark gray and some is dark brown. The darkest varieties are said to contain more iron and alumina than the light-colored material, and most of them are not steatite.

Megascopic impurities in some of the talc include limonite cubes that range from pin-point size to one-eighth inch, veinlets and coarse chunks of calcite, and inclusions of dolomite or partly altered limestone country rock. Talc containing these substances is sorted out. More commonplace but less serious are thin stains of iron oxide, which do not contribute appreciable amounts of iron unless very abundant. Some thin dendritic films of manganese dioxide are also found, but these are not harmful.

The run-of-mine ore is of steatite quality, and some of the select material is exceptionally pure. The following analyses, kindly furnished by the Sierra Talc Co., are representative of the quality being shipped as steatite:

	SiO_2	MgO	Al_2O_3	CaO	Fe_2O_3	*Alkalis*	*Loss on ign.*
Sierramic #1 --	59.61	30.01	1.65	0.84	0.92	0.26	5.94
Sierra Hi-Grade #1 --	60.56	30.19	1.46	0.80	0.90	0.22	5.68

The accompanying photomicrograph (fig. 8) shows one mineral impurity only, a minute crystal of sphene. Other specimens of the talc show sparse microscopic specks of sphene, leucoxene, and an unknown mineral that occurs in extremely small equant grains of low relief.

The steatite is essentially an aggregate of microscopic matted talc flakes, shreds, and stubby slivers, the last mainly showing a length-to-width ratio of 2:1 or 3:1. Most of the grains are only 0.005 to 0.025 millimeter long, and most are anhedral to subhedral. There is no obvious preferred orientation of the bulk of the tiniest flakes, but the larger grains exhibit one or two directions of imperfect parallelism. Some of the largest flakes and shreds (about 0.5 millimeter long) occur at random, but others form continuous, ill-defined, crooked streaks with the talc crystals oblique to the borders of the streaks. A few of the larger shreds are in splotches with a subradiating arrangement. The writer has not seen any relict textures inherited from earlier minerals. Many non-steatite talcs show remnants of tremolite, but the Talc City ore does not.

Occurrence. The geologic relationships of the talc are illustrated in the accompanying maps and sections, figures 9 and 10, plates 1-3. Without exception the talc is associated with the massive dolomite. Some talc is in or next to the residual islands of sedimentary rock surrounded by dolomite, but some is in the massive dolomite itself. Most or all the talc of steatite grade has been derived from massive dolomite.

More specific ore controls include the following: (1) Contacts between massive dolomite and stratified dolomite or limestone, (2) shears, and to some extent joints, within the massive dolomite, and (3) contacts involving the silica rock. Significant quantities of talc are found in places where only one of these three features is present, but all three ore controls are evident along parts of the large Central ore body.

The talc deposits are elongated, narrow, ragged, and irregular in plan and cross section. In a general way they dip steeply toward the southwest. Some have definite hanging walls or footwalls with polished and grooved surfaces, and with thick talc gouge. "False walls" are commonplace where the ore has been sheared and slickensided internally. Some talc masses have no distinct hanging wall or footwall; some have not even a moderately regular boundary, and in some masses, the contact with the country rock is gradational. Most of the ore bodies contain at least a few "boulders" (rounded inclusions) of dolomite.

Some large offshoots containing hundreds of tons of talc extend from the main bodies at unpredictable intervals. In contrast to the large offshoots, thin stringers of talc branch from the main talc masses, following joints; they rarely widen out into another ore body. On the other hand, stringers of talc within well-defined shears in a few places do lead to ore bodies. Even locally barren shears may serve as a possible guide to talc. One such shear, which is barren on the east side of the main ridge, may be followed to the Evening Star ore body on the west side of the hill.

The occurrence of talc along contacts between massive dolomite and stratified dolomite and limestone requires special mention. The talc frequently grades into country rock on the side towards the stratified material. As a rule there is an intermediate zone of "semi-talc," which may be scratched with the fingernail but which effervesces in acid, evidently being an intergrowth of talc and calcite. Within certain layers of this partly altered rock, true talc occurs in intermittent lenses a few inches in length. The talc in and near the stratified country rock is commonly dark brown and has stains of iron oxide, but the talk adjacent to the massive dolomite country rock is generally light-colored ore, is practically free of iron, and is of steatite quality.

Principal Ore Bodies. Although there are perhaps a score of talc deposits at Talc City, most of the production has come from three or four. Most of the others are quite small. In this report the westernmost large deposit (see map, pl. 1) is called the West ore body, the next one

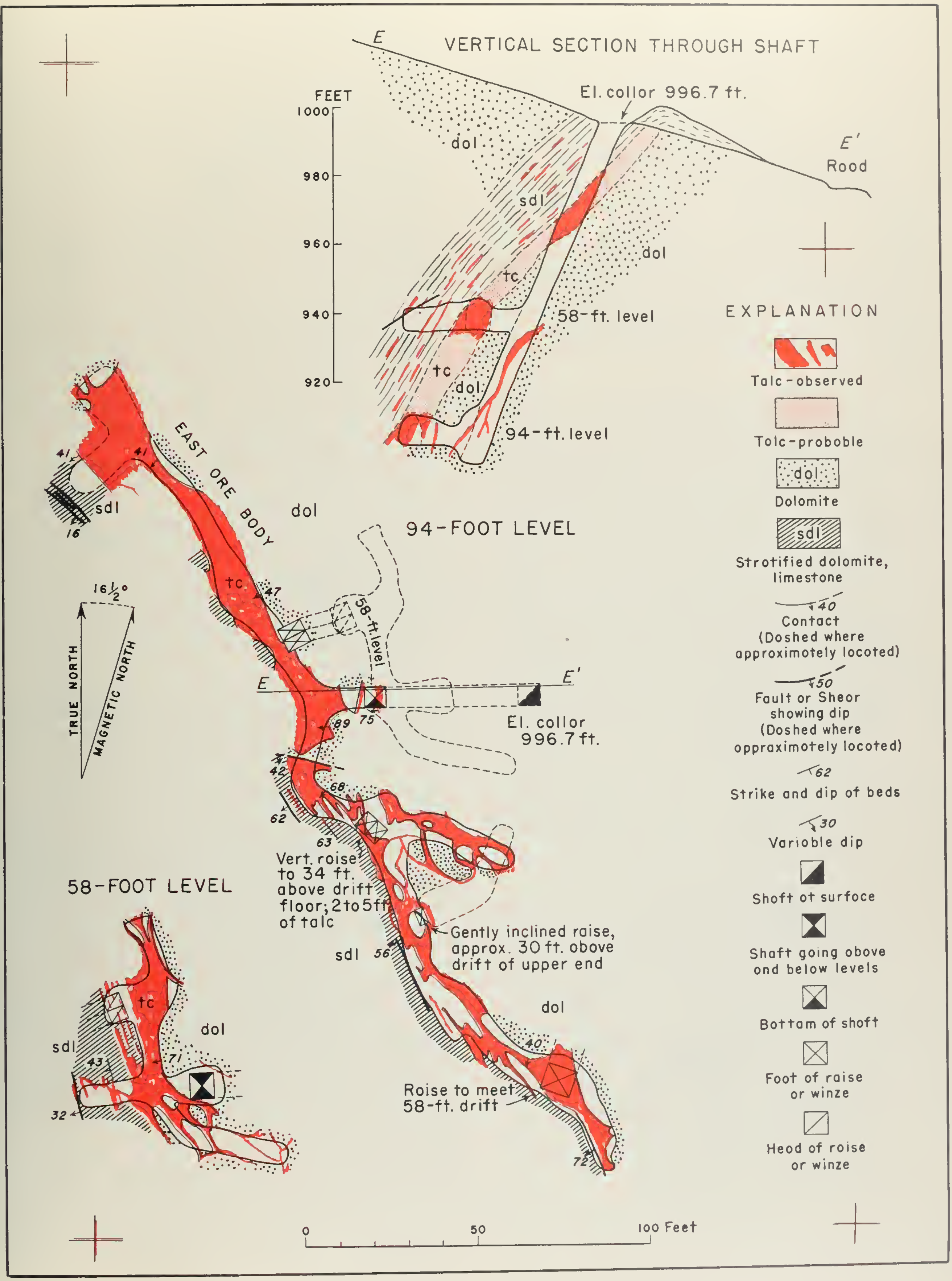


FIGURE 9. Geologic maps and section, East Side workings, Talc City mine.

to the east is called the Central ore body, and the deposit at the East Side shaft is the East Side [22] ore body. A few hundred feet north of these is the Evening Star ore body.

The West and Central ore bodies show a remarkable similarity in trend and geology, as indicated on the map. It might be supposed that they represent a single original deposit faulted into two segments, but this is not so. The country rock may have been repeated by faulting, but if it was, the faulting occurred before the talc was formed. The conjectured fault must have been a pre-dolomitization structure, as no vestige of such a feature in the massive dolomite is now exposed.

The West and Central ore bodies have yielded the larger part of the Talc City output. Widespread caving has made it impossible to trace all the former outlines of the ore accurately, but Mr. W. A. Reid obligingly added his recollections to the writer's piecemeal restoration. Intact remnants of talc still afford a good deal of first hand information.

The West ore body is said to have been exploited first, and was once considered worked out. It was mined largely by means of three glory holes. On the surface the talc comprised an elongated zone 550 feet long, between massive dolomite and stratified dolomite and limestone. Patches of silica rock of the hanging wall terminate at a shallow depth (pl. 3), probably having been altered to massive dolomite; the ore body also terminates at a relatively shallow depth at the localities explored to date. Only two downward prolongations of the ore were encountered at the B level. One of these was part of a wide bulge, and it had various offshoots. The bulkiest portion of the West ore body at the B level is said to have measured 40 by 60 feet in plan, but in many other places the width was only 5 or 10 feet. It is quite probable that additional undiscovered prongs of ore extend to depth south of the present B-level workings, but that region has not been explored. The writer believes that downward "roots" of the West ore body occur like the roots of a tooth. The south end of the ore body has moderately regular walls near the surface and dips steeply westward; the irregular, wide north end apparently was steeply inclined toward the west also. Although most of the northern portion is worked out, part of the southern half of this ore body was being mined above the A level at the close of 1942.

The Central ore body (pls. 1-3 and fig. 11) is more persistent at depth than the West body, but is otherwise similar. Although the heart of the deposit has been mined, this body is not worked out, and its ultimate depth is not known with certainty. The Central ore body extends at least from the surface to the workings below the D level, a vertical distance of almost 400 feet. According to reports, a crosscut 50 feet below the D level disclosed steatite ore; here again it is very likely that downward extensions occur discontinuously along the strike, and some of these probably reach below the present workings. On the surface this talc-bearing zone is 680 feet in length, but some parts are so narrow they cannot be mined. The southern part of the Central ore body lies between massive dolomite (the footwall), and stratified dolomite and limestone (the hanging wall). These relations prevail from the ground surface to the D level. The northern part of the Central ore body lacks a stratified hanging-wall formation at the surface and at the B level, but the stratified dolomite and limestone are present at the C level. The mass of stratified rock adjacent to the ore evidently plunges northward, so it extends much farther north within the mine than it does on the surface. Therefore it is possible that the talc deposit itself will have a greater length underground than on the surface. The northern part of the ore body, as now exposed, consists of a shear zone incompletely occupied by talc that in places is only a few inches thick, but which swells out locally to 5 or 10 feet. This northern part of the Central ore body is nearly vertical at the surface, but dips to the west at depth (pl. 3); it was being re-explored on the C level in 1942. The southern half of the Central ore body is thick in places, a width of about 40 feet being reported at one crosscut that is now caved. Large, irregular, intricate offshoots of talc occur in the massive dolomite footwall, and some of these can be mined.

The East Side ore body may possibly be a branch or a faulted segment of the Central talc deposit. The "watercourse" (open fault?) which is said to terminate the Central body, lies between the two deposits in the mine. However, on the surface of the ground no evidence supports the faulting hypothesis.

The East Side ore body is inconspicuous at the ground surface. Underground exposures show that it is an ill-defined, elongated lens with many inclusions of country rock (fig. 9). It dips 42°-62° SW., is 2 to 15 feet thick, and in late 1942 was developed for more than 180 feet along the strike and 100 feet down the dip. The stratified rocks of the hanging wall contain thin streaks of talc, making the west boundary of the ore rather vague. The footwall boundary is even less distinct, as talc containing dolomite inclusions grades into dolomite with interlacing talc stringers.

The fourth ore body has been mined at the Evening Star glory holes (pls. 1 and 3). The talc that was first produced from this ore body was not considered entirely satisfactory for steatite, and about half of it was rejected because of limonite cubes and stains. However, after 1942 acceptable steatite was mined from the deposit. As in the occurrences described above, the Evening Star ore body is bordered by massive dolomite on one side, and by stratified dolomite and limestone on the other side. Silica rock is present also. The talc-bearing zone is not as linear in plan as the other three ore bodies except at the west end, which is a steep shear containing only a foot or so of talc. The eastern end of the Evening Star ore body is in part a bulge on the same shear, but the major mass of talc is a stubby branch. The ore body was formerly said to extend downward as a funnel to a depth of only 40 feet below the surface, but this has been disproved by exploration since 1942. Mr. Henry Mulryan states that a wide continuation of the deposit has been found at depth. At the surface, the ore ends toward the east against an almost unbroken barrier of massive dolomite, but, juding from the West ore body, the subsurface extent of the Evening Star deposit will prove to be quite different from the extent on the surface.

Probable Downward Continuation of Ore Bodies. Because the neighboring limestone in the vicinity of the Talc City mine may be an ancestral rock without which the talc might not have developed, the former downward extent of the limestone is of importance. The remnants of limestone all dip steeply and have very little curvature,

[22] Not to be confused with the East End talc mine less than a mile away.

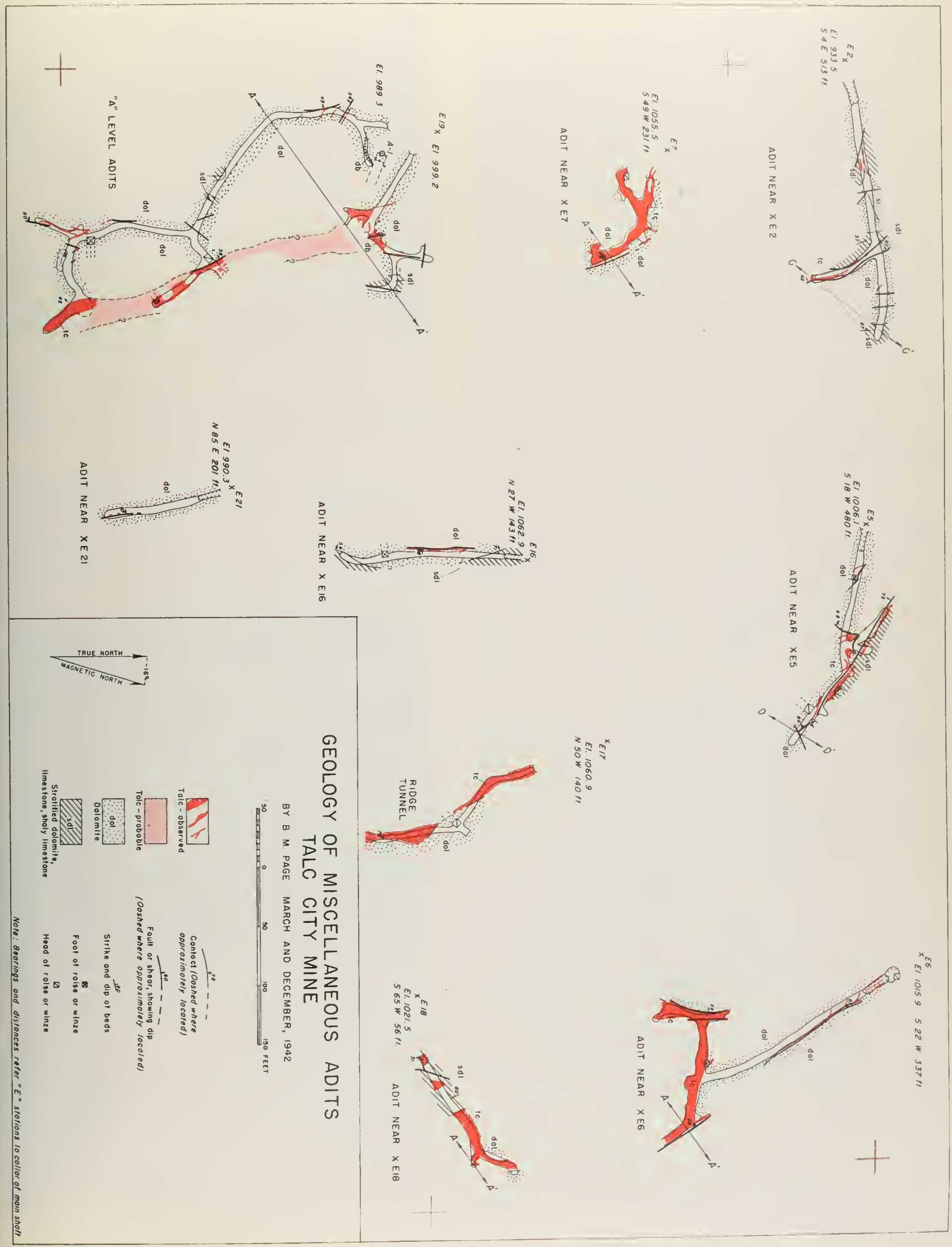

GEOLOGY OF MISCELLANEOUS ADITS
TALC CITY MINE
BY B. M. PAGE MARCH AND DECEMBER, 1942
50 0 50 100 150 FEET
TRUE NORTH
MAGNETIC NORTH
Talc - observed
Talc - probable
Dolomite
Stratified dolomite, limestone, shaly limestone
Contact (Dashed where approximately located)
Fault or shear, showing dip (Dashed where approximately located)
Strike and dip of beds
Foot of raise or winze
Head of raise or winze
Note: Bearings and distances refer "E" stations to collar of main shaft
"A" LEVEL ADITS
ADIT NEAR X E2
ADIT NEAR X E7
ADIT NEAR X E5
ADIT NEAR X E6
ADIT NEAR X E16
ADIT NEAR X E21
ADIT NEAR X E18
RIDGE TUNNEL
El. 933.5
S 4 E 513 ft.
El. 1055.5
S 49 W 231 ft.
El. 989.3
El. 999.2
El. 1006.1
S 18 W 480 ft.
El. 1015.9 S 22 W 337 ft.
El. 1062.9
N 27 W 143 ft.
El. 990.3
N 85 E 201 ft.
El. 1060.9
N 50 W 140 ft.
El. 1021.5
S 65 W 56 ft.

FIGURE 10

indicating that the limestone once extended downward a great distance: the massive dolomite derived from it is probably likewise vertically persistent, comprising a great volume of rock suitable for the formation of talc. If the granitic rock exposed to the south extends beneath the Talc City mine at depth, the upper surface of the underlying granite may be one of the limits of the talc-bearing zone, but its general position at present can be inferred only. The massive dolomite is not noticeably coarser at the C level than at the B level, offering no indication that an igneous intrusion is very close. Similar negative evidence is afforded by the lack of lime-silicate minerals in the massive dolomite. Pyrite, and limonite pseudomorphs after pyrite, are numerous in some of the deepest ore now exposed, but they are equally prominent in some of the talc at the surface of the ground. Finally, relatively few dikes are found in the mine, but dikes are plentiful near the granite contact half a mile south of Talc City. These conditions seemingly indicate that the upper surface of the granite has not been closely approached by the mine workings.

The foregoing facts do not demonstrate that talc will extend downward indefinitely, for temperature and pressure conditions and other factors undoubtedly played an essential part in the control of ore formation. However, it is likely that ore occurs at least a hundred feet, and probably several hundred feet, below the present workings.

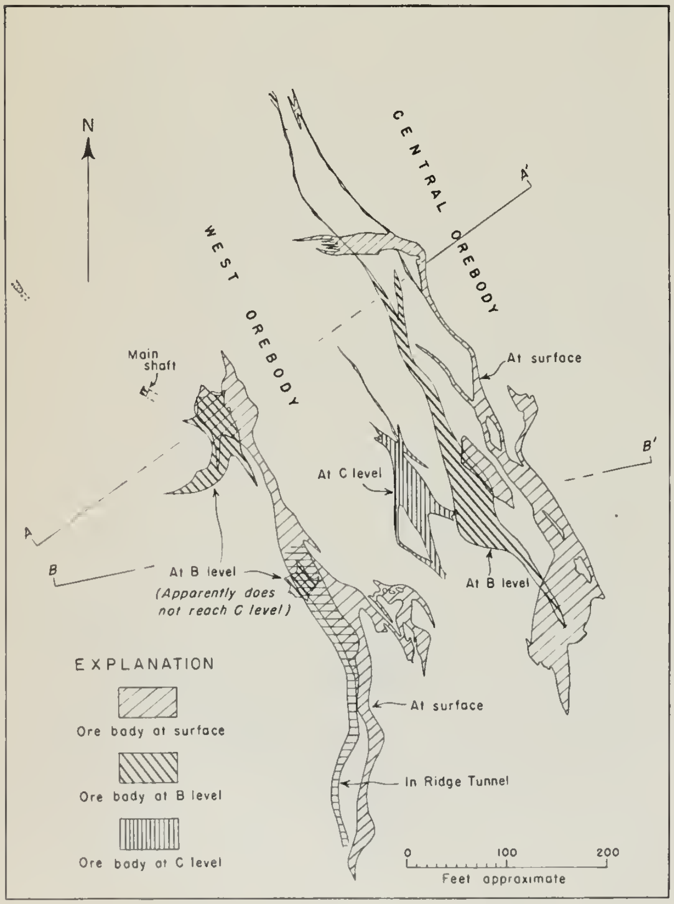


FIGURE 11. Generalized diagram of parts of the West ore body and Central ore body, Talc City mine, showing variation in shape with depth. Composite map based on incomplete data, 1942.

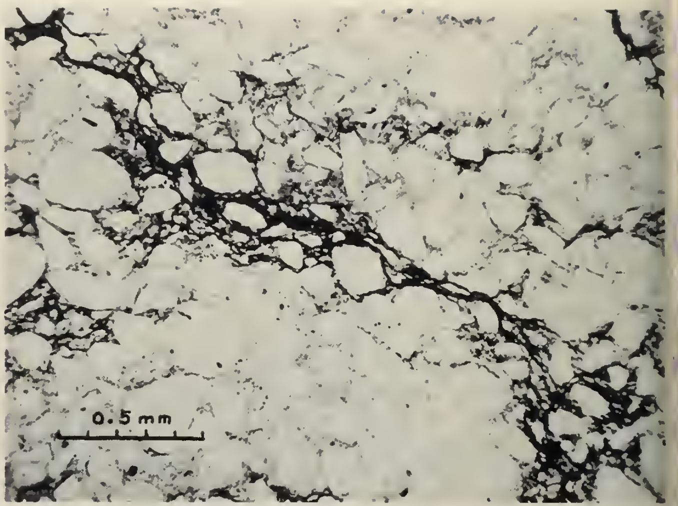


FIGURE 12. Photomicrograph of silica rock from the Alliance mine showing sand (?) grains of quartz with later rims of chlorite. Incipient mylonitization is indicated. The braided black streak bisecting the picture is a micro-shear zone, consisting of coherent pulverized matter. This rock is the host rock for talc in the Alliance mine. Uncrossed nicols.

Alliance Mine and Irish Lease

The Alliance mine and Irish lease are on adjoining claims slightly more than half a mile north of the Talc City mine, and 6 or 7 miles northwest of the city of Darwin. They are about 5,300 feet above sea level, and are reached by road from Lone Pine and Keeler. Lauren A. Wright and the author studied these properties during a period of 4 days in December 1942.

The Rocks of the Area. The areal distribution of the rocks is shown in figure 12. Limestone, dark gray and distinctly stratified, occurs in the south part of the map area. Poorly preserved crinoid fragments were found in some places. Outcrops are gray to buff, and are numerous but not very prominent. Most of the limestone underlies sandstone and slate, described below, but some is also found above the slate.

Sandstone, thin-bedded and in part shaly and reddish, overlies the main mass of limestone in at least one place on the Irish lease. It is only 5 or 10 feet thick, and is included with the slate on the geologic map.

Slate, mainly dark gray or greenish gray, overlies the thin sandstone member along the southern border of the map area. Slate or other argillaceous material probably once existed in other places at the site of the Alliance mine, as some of the profoundly altered rocks in and near the workings are dark and rich in alumina. One such altered rock, although granulated almost beyond recognition, appears to have been a silty argillite; it is exposed near the footwall of the talc deposit near the Palmers' new shaft.

Massive dolomite is the most abundant rock in the northern part of the map area. For the most part it is devoid of bedding and is everywhere barren of fossils. It is fine to medium in grain size, compact, and tough. Outcrops are plentiful; they vary from pale gray to buff and gray black, and exhibit harsh surfaces with tiny projections and depressions. The massive dolomite is a hydrothermal alteration or replacement of limestone. Near the talc some of the dolomite has been changed to soft, white, non-talcose substance.

Silica rock forms the central part of the mine area and is topographically the most prominent material, appearing in numerous bold outcrops which weather brown. Its contacts with dolomite are very sharp in many places. Probably the silica rock is a quartzite, as locally indicated by rounded to subangular grains of moderately uniform size (fig. 12), but some specimens contain closely fitting quartz grains with mutually embayed boundaries (fig. 13).

Interesting alteration products in the silica rock are associated with the Alliance talc deposit. Initial petrographic study points to the silica rock as the original material in most places. The quartz was sheared (fig. 12) and mylonitized in places, and was then hydrothermally altered. The resulting rock is much darker than the unaffected silica rock, and in fact bears scarcely any megascopic resemblance to it. The altered rock is dark gray, in some places tinged with dull green, and may be scratched with steel. In it are residual quartz grains, which commonly predominate over the other constituents, but are somewhat masked by them. Some of the quartz grains are "frayed", having been partly chloritized. Chlorite aggregates encircle these frayed grains, and fine chlorite mosaics are also localized in rounded areas. The finest constituents of the rock have not been determined, and the composition of the wispy, black, mylonitic streaks is unknown.

A further, or perhaps parallel, alteration of the silica rock has produced most of the talc at the Alliance mine.

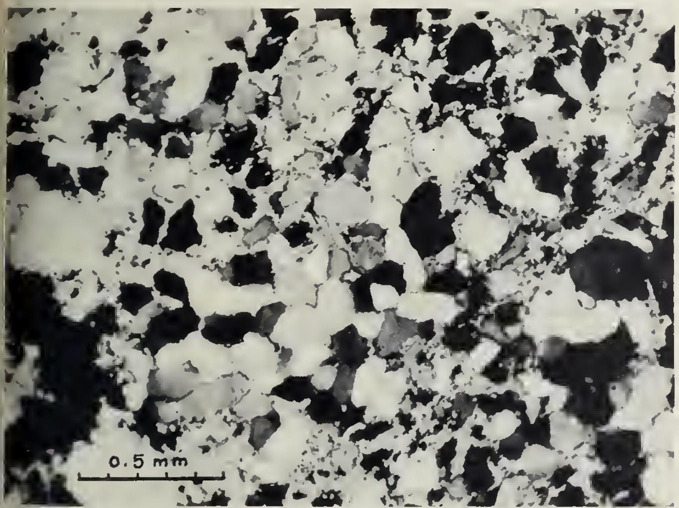


Figure 13. Photomicrograph of silica rock from the Alliance mine, showing incipient development of talc, which has attacked the quartz grains. Crossed nicols.

Geologic Structure. The most important structural relations are those of the central mass of silica rock, which is apparently bordered by faults both on the south and on the northwest, as explained below. Talc occurs along both of these fractures. The Alliance mine is on the northwest fault, whereas the Irish lease is on the south fault.

South of the silica rock, the limestone and slate dip northward against the main mass of silica rock (fig. 15). Therefore a fault exists along the discordant contact, unless the silica rock is an alteration product of the lime-

Figure 14. Photomicrograph of steatite from the Alliance mine. The only mineral shown is talc, but two or three other minerals occur in minute quantities elsewhere in the specimen. Uncrossed nicols.

stone and slate strata which run into it. The fault, if such it is, was formed prior to the hydrothermal activity that produced talc along the border of the silica rock, and is now completely healed.

The northwest edge of the silica rock is bordered by soft altered rocks and by talc, beyond which is massive dolomite. The soft altered rocks have developed along an east-northeast shear, and some renewed displacement has occurred. Slickensided surfaces are widely distributed in the altered rocks, but the most persistent plane of movement is that which forms the hanging wall of the principal talc zone; this fault surface dips gently northwest, away from the silica rock, and passes beneath the massive dolomite.

Elsewhere, the border of the silica rock is not a fault contact, although many portions are relatively straight and decidedly discordant with respect to the strike of the nearest stratified rocks. No gouge, breccia, slickensides, or shears are present; the silica rock and adjacent massive dolomite are not separated by so much as a single crack in many places. The outline of the silica mass is well exposed, and its shape shows that faulting or at least post-alteration faulting cannot account for the strange shape and distribution of the silica rock.

Alliance Mine

Ownership and History. Mrs. Edith Lockhart and George Koest of Darwin, California, are the owners of the Alliance mine, but lessees have carried on all operations. The Sierra Talc Company worked the deposit in 1939; subsequently M. C. Williams has been the lessee. Mr. Williams operated the mine in 1940-41, then sub-leased it to the U. S. Diatom Company in 1941-42, and to the Palmer Development Company in 1942. The latter company achieved the largest share of the total production, which is estimated to have been slightly over 4,500 tons by the end of 1942. Probably at least half of this tonnage was sold for radio ceramic steatite.

Mine Workings and Operation. The surface workings are shown in plate 4. The large open pit undoubtedly was the site of earliest operation. In part the pit was worked as a glory hole, tapped by shallow adits.

An inclined shaft near the glory hole extends to a depth of 70 feet, and two levels connect with it (pl. 5), one at 45 feet and one at 70 feet. Most of the 45-foot level is now inaccessible. The workings at the 70-foot level comprise about 450 feet of drifts and crosscuts. From these there are several raises and large, gently dipping stopes that have been supported in places by square sets but which more generally have been allowed to cave. Remnants of an inclined winze may be discerned on the 70-foot level (pl. 5). This winze is said to have been sunk 40 feet in ore.

The talc, in 1942, was sorted at the mine into two grades "black" and "white," and sent by truck to Keeler. Here the dark variety was shipped by rail for milling, but the light was bought and milled at Keeler by the Sierra Talc Company. The light-colored talc was used in electrical ceramics, but the dark talc was used for other ceramics and for fillers.

The Ore Zone. There is no single all-inclusive mass of talc at the Alliance mine, but if semi-talcose rocks are included there is a principal ore-bearing zone (pl. 5). This ore zone has formed along a system of shears; it lies between the main body of silica rock and the adjacent expanse of massive dolomite, and it dips gently northwest beneath the dolomite.

The soft hydrothermal products in the ore zone form a belt about 30 feet thick, and include dark-gray chloritic substances derived partly from silica rock and partly from slate or argillite, light-colored, softened, semi-talcose silica rock, and nearly pure talc.

The talc has few distinct boundaries. It appears and disappears by gradation within the altered zone. Unlike the talc of the Talc City mine, it has been formed as a replacement of the silica rock. Well-defined masses or lenses of talc can rarely be found, as there is a general erratic blending of talc and semi-talc. However, shapeless masses of talc large enough to permit mining are encountered commonly. The one distinct boundary of the talc-bearing zone is its fault contact with the massive dolomite of the hanging wall.

Nature of the Talc. There are two varieties of ore, the light-colored and the dark. The light-colored talc varies from white to gray, and is frequently mottled; the dark talc is dark gray to black. Both types are somewhat blocky, but are cut in all directions by many incipient cracks. There is no schistose, platy, flaky, or fibrous texture visible to the naked eye. The grain size is very fine (fig. 14), most of the talc particles being 0.005 to 0.02 millmeter long. Numerous pseudo-spherulitic clusters of subradiating grains are about 0.04 millimeter long. These are not shown in the photograph. Some of the clusters are elongated and some are composite, and in places they almost touch one another. The only minerals other than talc noted by the writer were a few small grains of sphene, a trace of leucoxene, and extremely small equant specks of low relief.

The talc is translucent on the thinnest edges only. Color is of no assistance in distinguishing the ore from associated semi-talcose rocks, and about the only simple criteria are "soapy feel" and softness of the talc, in comparison with the adjacent materials.

The light-colored talc, which probably constitutes 30 percent to 50 percent of the ore in the Alliance mine, is steatite used for radio electric ceramics. It has been analyzed by the Bureau of Mines, which very kindly provided the results below:

U.S.G.S. No. 30—Alliance mine. From stope on 70-foot level Collected by Page, 5/1/42. About 100 lbs. of light-colored ore CaO, 0.13%; Fe_2O_3, 0.80%. Color fired 2,300° F, light cream some specks. 2% impurities.

The dark talc probably has not been used for radic electric purposes. It is said to be relatively high in alumina, and may therefore contain pyrophyllite or chlorite. The Bureau of Mines supplied the laboratory results shown below, but evidently made no test for alumina.

U.S.G.S. No. 68—Alliance mine. Collected by Wright and Page from ore pile; about 20 lbs. CaO, 0.16%; Fe_2O_3, 0.74% Color fired 2,300° F, light cream. Mineral impurities, very low; abrasion, soft.

These interesting results show that the calcium and iron content of the dark talc is essentially the same as that of the light-colored talc, and that this dark ore burns light. The dark talc may be steatite even though it is not marketed as such.

The Alliance ore is more chunky and less brittle than that of the other nearby mines, and would appear to be more suitable for lava-grade block talc. The Geological Survey submitted block specimens to M. Kirchberger & Co., Inc., for machining and firing tests. The Survey's samples and Kirchberger's results are shown in Table 2.

Irish Lease

This property, immediately adjacent to the Alliance mine, is owned (as of 1942) by Mrs. Eva Irish, 929 South Detroit Street, Los Angeles, California. When visited by the writer it was operated by a lessee, W. J. Quackenbush of Darwin, California.

Development at the claims has all been recent, apparently, and on a very small scale; the entire production has amounted to only a few hundred tons. As shown in plate 4, there are four shafts, three of which are scarcely more than deep pits (8 feet, 17 feet, and 19 feet deep, respectively). The fourth shaft, very close to the others, was more than 35 feet deep in May 1942, and was connected with short drifts which are shown in part in figure 15.

Occurrence and Nature of the Ore. All workings lie along or near the contact between silica rock and slate (pl. 4, fig. 15), where a zone of alteration includes discontinuous masses of talc. The slate dips at an angle of 50°-60° into the silica rock with a discordance of about 20° between the two, and it is likely that a fault existed here prior to the formation of the talc.

The talc, more or less enveloped in partly softened rock, occurs in irregular streaks, blebs, and masses that are generally distributed in an elongated zone, but which individually are not all parallel with the zone. The talc-bearing ground is at least 35 by 250 feet in plan, but only a small portion is actually talc. Most or all of the talc originated from the alteration of silica rock.

The ore is fine-grained, soft, and blocky; it is more opaque and more nearly pure white than the Alliance product. The Bureau of Mines has kindly made an analysis which is as follows:

U.S.G.S. No. 67—Irish lease. Collected by B. M. Page from loading chute (weight about 20 lbs.). CaO, 0.16%; FeO 1.16% color fired 2,300° F, buff; mineral impurities, very low, abrasion, soft.

Table 2

No.	*Where collected*	*Weight in pounds*	*Original color*	*Firing tests*	*Iron oxide*	*Machine-ability*	*Conclusion*
All-1	Sierra Talc Co. mill at Keeler	3½	Mottled gray	Satisfactory	Low	Good	Best *
All-2	Sierra Talc Co. mill at Keeler	9¼	Black	Satisfactory	Low	Good	Fair
All-3	100-level	4¾	Dark gray	Satisfactory	Low	Good	Good
All-4	Carlson raise in mine	7¾	Dark gray	Satisfactory	Medium	Good	No value

* This sample was the best of 22 samples tested from steatite-producing mines.

Thus the ore appears to be well within steatite limits in all characteristics for which it was tested. The actual use of the talc, however, is unknown to the writer.

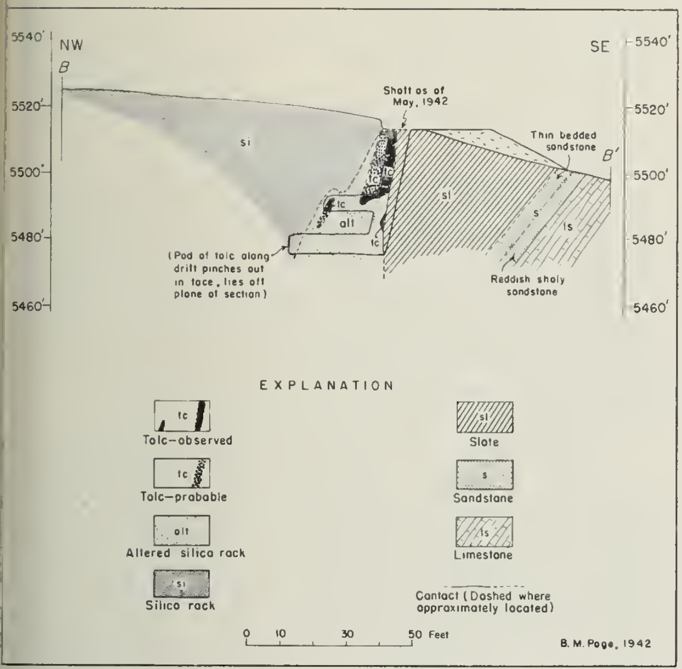


FIGURE 15. Cross-section B-B' of the Irish lease, Inyo County, California.

White Mountain Talc Mine [23]

The White Mountain mine was studied by L. A. Wright and B. M. Page during 5 weeks in August and September 1942.

The mine is within and adjacent to an unnamed canyon on the east side of the Inyo Range, Inyo County, California (fig. 3). It is reached by road via Lone Pine and Keeler, the latter village being only 8 or 9 miles away by direct line, but 35 or 40 miles by road. More than half the road is unpaved and a part is very steep. The altitude of the area (between 6,000 and 7,000 feet) is such that surface operations are hampered by snow in the winter. Above the mine are spectacular limestone cliffs near the crest of the Inyo Range (fig. 16). The area is in the belt of juniper and piñon, which were formerly used for timbering the mine workings. The White Mountain mine has a scanty water supply, which is piped a mile or two from a high spring above the camp.

[23] This section has been compiled from a report by Lauren A. Wright and Ben M. Page.

It is said that the White Mountain talc was known to Indians and that some was sold by them to the old and famous Cerro Gordo mine for use as a refractory. In 1914 Roy C. Troeger of Los Angeles, California, claimed the deposit, which was named the Cerro Gordo Soapstone. Mr. Troeger was still the owner of the mine in 1942, but had never operated it. It was virtually undeveloped until some time in the 1930's when it was leased by the Sierra Talc Company, which came into ownership of the Florence and Mae West properties nearby. Mining of the White Mountain talc was found to be unprofitable to the company, so the lease was given up after about 5 years. Ownership of the Florence and Mae West was retained, but no subsequent work on those two properties has been done directly by the company.

William Bonham of Line Pine succeeded the Sierra Talc Company as operator of the White Mountain mine, which he has leased since 1938 from Roy Troeger. Under this arrangement the mine has become one of the few producers of steatite in the United States.

Brief notes concerning the White Mountain mine have been published by Tucker and Sampson.[24]

Mine Workings and Operation. There is no integrated system of workings at the White Mountain mine; instead about 40 adits, many of which were begun for prospecting purposes, are scattered over an area of 30 acres. Most of the adits show at least traces of talc, but few have exposed minable bodies. The one place where interconnected workings once existed is in the central part of the mine, where the Sierra Talc Company drove a tunnel and worked one or two additional levels. The portals of this tunnel are labeled 8 and 16 on the accompanying map, plate 6. (All such numbers are arbitrary designations by the writer.)

The Sierra Talc Company mined from the glory hole above the aforementioned tunnel, and from a small glory hole near adit no. 2. Most of their production came from the larger glory hole. The company also drove part of adit no. 36 and sank a 30-foot shaft, now caved and obliterated, near adit no. 24. As they were unable to apply large-scale methods of mining, the company abandoned the operation. Nearly all of the subsequent workings have been made by William Bonham.

Mr. Bonham discovered a steatite ore body just beneath the ground surface and just above the old tunnel driven by his predecessors. The removal of this ore left "the Big Room" (see pl. 6). Since the exploitation of "the Big Room," mining and prospecting have sometimes consisted of "gophering" by a crew of four to eight men. Hand drilling is preferred, most of the rock being soft or well fractured. When ore is found it is usually

[24] Tucker, W. B., and Sampson, R. J., California Div. Mines Rept. 34, pp. 492-495, 1938.

taken out by wheelbarrow or by mine cars and dumped directly into a truck, which takes it about 40 miles to the Sierra Talc Company's mill at Keeler. Selective blasting and shoveling are employed, but no hand sorting is done.

During the time of the writer's investigation a small amount of ore was mined from adits numbered 11, 28, and 29 on plate 6. No ore was blocked out ahead of mining.

Production. The Sierra Talc Company produced less than 100 tons a month from the White Mountain mine and probably reached a total of 2,000 to 5,000 tons. Under the present system, about 200 tons a month is being shipped and it is thought that Mr. Bonham has produced altogether 3,000 to 6,000 tons. This would make the output of the White Mountain mine between 4,000 and 10,000 tons, during a period of approximately 10 years up to the end of 1942.

Despite the difficulties of its operation, the mine was one of the two producers of steatite in the United States at the opening of World War II, and it still holds an important place in the industry. By agreement, the Sierra Talc Company has the exclusive privilege of buying the talc.

Rock Units. The rocks at the White Mountain mine represent a thick sedimentary section that has been faulted and subjected to igneous intrusion and hydrothermal alteration. Certain stratigraphic relationships are therefore indistinct. The sedimentary rocks contain no recognizable fossils, but a Paleozoic age is assumed from the presence of crinoids, corals, and brachiopods in nearby formations of similar lithology. Alteration near the talc-bearing zone has locally converted some rock varieties to white, pulverent materials, and in some cases the original rock cannot be determined.

FIGURE 16. Part of the White Mountain mine. Camera facing southwest. *Photo by L. A. Wright.*

1) Banded Limestone. A white and light gray-banded and stratified limestone that occurs in isolated masses within a massive dolomite is assumed to be the oldest of the rocks near the mines. It is exposed in the southwest corner of the White Mountain area, is separated from the other sedimentary units by a fault, and bears no relation to the talc bodies. It is the only non-magnesian limestone in the vicinity and undoubtedly represents the relatively unaltered portions of a rock now largely dolomitized. Local distortions occur within the limestone, but cannot be recognized in the surrounding dolomite.

2) Flinty Dolomitic Limestone. A gray to black, fine-grained flinty dolomitic limestone is the oldest rock east of the above-mentioned fault, within the mine area. The flint occurs in varying abundance as thin, discontinuous, irregular layers which are generally the main indications of bedding. The upper portion of the limestone is in places characterized by well-defined bedding planes and by the absence of flint. This is shown in the workings of the White Mountain mine north of the main canyon.

Hydrothermal processes related to or contemporaneous with those producing the talc have altered parts of the flinty dolomitic limestone in the immediate neighborhood of the ore bodies. The two most common products of this wall-rock alteration are: (1) a gray, soft, micaceous rock superficially resembling shale, and (2) white, fibrous aggregates of tremolite and other silicates. Flint, where present, has remained unchanged in both types of alteration.

3) Sandy Dolomite. A gray sandy dolomite that weathers to a buff color occurs stratigraphically higher than the flinty dolomitic limestone at the White Mountain mine. An uncomformable relationship is possibly indicated by a locally exposed angular discordance and angular flinty dolomitic limestone blocks within the sandy dolomite at one place. The sand occurs as well-rounded grains in layers which are in places cross-bedded. These layers, although difficult to recognize on fresh surfaces, are brought into prominent relief by weathering.

4) Silica Rock. A white to light-gray, massive silica rock occurs at several horizons in and above the upper portion of the flinty dolomitic limestone, and commonly separates the limestone from the overlying rocks. The silica rock is composed essentially of quartz, is generally associated with the most highly altered rocks, and is found near most of the talc occurrences at the White Mountain mine. These relations, together with its discontinuous distribution, would seemingly indicate a hydrothermal origin. The same inference may be drawn from the "jig-saw" texture of some specimens (fig. 17). However, a sedimentary origin is suggested by possible bedding planes, and by the rounded grains of quartz in some specimens.

5) Massive Dolomite. A massive, coarsely crystalline, white, light-buff or gray dolomite occurs at the White Mountain mine; it is coarser and somewhat paler than that at Talc City. All such dolomite has been mapped as a single unit although probably several sedimentary rock types have been dolomitized. Gradational contacts exist between the massive dolomite and both the sandy dolomite and banded limestone.

A large portion of White Mountain talc occurs in a zone near the contact of the massive dolomite with the adjacent rocks.

6) Dikes and Sills. Igneous rocks composing dikes and sills appear to be of two or more kinds. The central dike (pl. 6) is an intensely altered rhyolite or andesite with remnants of hornblende needles, vague outlines of feldspar phenocrysts, and specks of pyrite and limonite.

Fine chlorite occurs fairly abundantly in the dike. The rock is gray at depth, but near the surface the characteristic color is rusty and mottled.

Some of the sills in the area are probably basic andesite in composition, consisting of plentiful altered feldspar phenocrysts and indeterminate groundmass minerals, with pyroxene converted to chlorite. These sills are greenish in color.

7) Mantle. A mantle covers large portions of the area. In some places it is simply thick soil, in others it is landslide, mudflow, or talus material. It consists in some places of a single rock type, most commonly massive dolomite or silica rock, large boulders of which often appear to be nearly in place. In such places, however, the underlying rock is not invariably the same type as that which predominates in the mantle.

The mantle has an observed maximum thickness of 15 feet where it is cut by the mine workings, but it is probably thicker elsewhere. Talc deposits, undiscovered as yet, may be completely covered by the mantle.

Geologic Structure. Most of the structural features are shown on the map (pl. 6) and on the geologic cross sections (pl. 7).

The White Mountain mine lies within a zone of northwest-trending faults which vary in size and continuity. These faults have, as associated structures, innumerable small, discontinuous shears with non-uniform and very diverse attitudes. Folding is secondary in importance and is partly the result of drag along the larger fault planes. Several of the faults are of sufficient size to be recognized on the surface although their traces are partly obscured by alluvium and mantle. The three most important of these have been designated as (1) the western fault, (2) the eastern fault, and (3) the central fault zone.

The western fault, which is the largest and apparently the most structurally significant of the three, traverses the southwest corner of the area and can be traced to the northwest for more than a mile. Future mapping may show that it is a Basin and Range type of fault. It is characterized by a zone of dolomitic breccia and elongated dolomite blocks; this zone, within the area, averages 80 feet in thickness and separates massive dolomite with its associated banded limestone on the southwest from similar dolomite and talcose silica rock on the northeast. The fault has a nearly vertical dip where it is exposed underground. The talc bodies are limited to the area northeast of the fault and similarly the banded limestone occurs only to the southwest of the breccia zone. Post-talc movement truncating the ore-bearing zone is inferred, as no hydrothermal effects are localized along the fault.

The eastern fault, which also probably is of regional importance, crosses the northeast corner of the area. Mantle, however, covers a portion of its northwest extension. Where best exposed south of the main canyon, the eastern fault is a brecciated zone averaging 20 feet in width. It is bordered on the northeast by massive dolomite and on the southwest by flinty dolomitic limestone. The fault dips gently westward in exposures near the main canyon, and steepens southeast of the canyon. A small andesite dike closely parallels the trace of the fault for a distance north of the canyon, and suggests the presence of an ancestral fault prior to the igneous intrusion. No talc bodies have been localized along the fault, however, and it is probable that its more recent movement occurred after the emplacement of talc.

The central fault zone, which is partly occupied by a dike, traverses the central portion of the area. It intersects two of the main talcose areas and in places contains talc. Recurrent movement has sheared and intimately fractured the dike, and has apparently caused masses to be separated from the main body. Underground exposures indicate a great local variance in the direction of strike and degree of dip of the dike and associated faults. Drag along the northeastern boundary of the dike has commonly produced parallel anticlinal folding in the flinty dolomitic limestone and indicates a relative upward movement of the rock on the northeast side.

One fault of the central zone is known to the miners as the "Black Wall" (see section B-B′, pl. 7). It closely parallels the southwestern border of the dike in the vicinity of the glory hole. It is locally well exposed both on the surface and underground but cannot be extended with certainty for a great distance in either direction. Wherever recognized, the "Black Wall" consists of a zone of gouge and breccia of varying width, separating black flinty dolomitic limestone from light-colored silica rock. Talc occurs not only as crushed material within the faulted zone but also as discontinuous bodies within each wall rock. The fault changes in attitude from a northwest strike and a vertical dip in its southernmost exposure to an east strike and a gentle southward dip where last seen to the west.

Whether the "Black Wall" fault existed as a structural feature which localized the talc, or whether it developed because a talcose contact zone offered the easiest relief to stresses is not certain. Obviously some movement has taken place since the formation of the talc. If the fault antedates the talc, the "Black Wall" may be expected to extend southeastward with a reasonable degree of persistence beneath the mantle and at the same time retain its talcose nature. If the fault is younger than the talc, however, it would probably change its direction of strike to conform with the talcose border of the silica rock, or would distribute itself into a number of small barren shears.

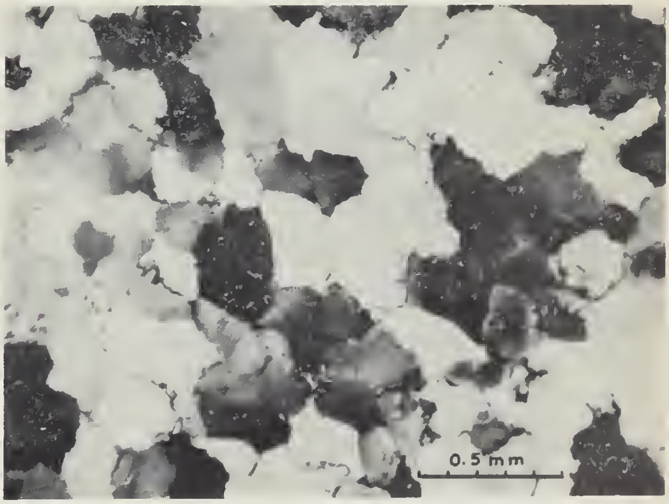


Figure 17. Photomicrograph of silica rock, White Mountain mine. The principal mineral is quartz, in interlocking grains showing incipient rims of talc. Crossed nicols.

The Talc. The White Mountain talc occurs as several varieties, which may be grouped into three main categories according to color as follows: (1) light-colored talc, (2) moderately dark talc, and (3) "black" talc.

(1) The light-colored talc is white to gray white to tan, the last tint being common near the surface of the ground. Most of the light-colored talc is fine-grained, and except where sheared it lacks foliated or platy structure and breaks into irregular lumps. In places the texture is coarse enough to impart a very fine sugary appearance. The light-colored talc is softer than the fingernail but harder than some other talcs, and is less brittle than the Talc City material, which it approaches chemically. An analysis furnished by the Sierra Talc Company is as follows:

	Percent		*Percent*
SiO_2	61.40	MgO	31.21
Al_2O_3	1.57	Na_2O and K_2O	.19
Fe_2O_3	.90	Loss on ignition	5.09
CaO	.40		100.76

This composition, together with other favorable characteristics, places the talc among the best grades of steatite.

This high-grade talc is derived not from the dolomite, but from silica rock. This is graphically indicated in figures 17 and 18, which illustrate the steatization of silica rock. Because of this origin, the main impurity found in the talc is quartz, rather than carbonates or tremolite which occur in many types of talc.

The chunky and relatively tough nature of certain varieties of the ore, together with the favorable composition, make some of it suitable for lava-grade block talc. The Geological Survey submitted block samples to M. Kirchberger & Co., Inc., for testing. The results are as follows:

No.	*Where collected*	*Wt. in lbs.*	*Firing test*	*Iron oxide*	*Machine-ability*	*Conclusion*
WM-1	Mill at Keeler	4½	Satisfactory	High	Good	No value
WM-2	Mill at Keeler	4½	Unsatisfactory	Medium	Good	No value
WM-3	Mill at Keeler	17¼	Satisfactory	Medium	Good	Good
WM-4	Mill at Keeler	5	Satisfactory	Medium	Good	Fair
WM-5	Mill at Keeler	9	Satisfactory	Low	Good	Good

Although the foregoing data are not all favorable, the results are better than those obtained from most other California talc. No megascopic defects were noticed in the unsatisfactory samples prior to firing, but further experience might enable one better to evaluate the material before actual testing.

(2) The darker talc is a neutral gray, but otherwise resembles the light-colored talc superficially. When ground it yields a white powder. This type of talc was formerly not accepted for radio ceramics, but in 1942 some of it was included in shipments of steatite. A sample (U.S.G.S. no. 41) was sent to the Bureau of Mines for analysis and was found to contain only 0.07 percent CaO and 0.58 percent Fe_2O_3.

(3) The "black" talc is dark gray, but underground it appears to be black. When ground it yields a grayish-white powder. It is more brittle and more thoroughly fractured than the other two types, commonly occurring in fragments an inch or two in length. It is always associated with dark dolomitic limestone and is believed to have retained the pigment of the limestone. Very little importance has been attached to this talc, partly because it is not abundant, but some has found its way into steatite shipments. A sample (U.S.G.S. no. 40) was sent to the Bureau of Mines for analysis; the CaO content was 0.88 percent, and the Fe_2O_3 was 1.06 percent, so these two impurities fall within the range permissible in steatite.

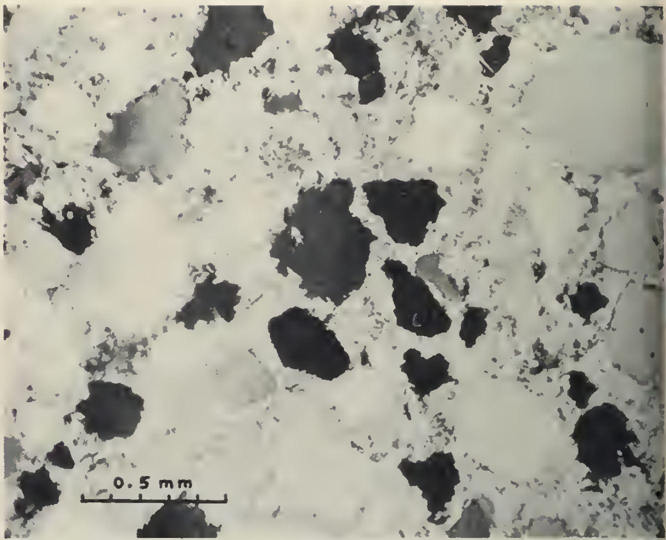


FIGURE 18. Photomicrograph of silica rock partly altered to talc, White Mountain mine. The large grains are quartz, with frayed and embayed edges because of partial replacement by talc, which is the fine interstitial material. Crossed nicols.

There are also small quantities of decidedly green "talc" in and along some of the dikes and sills. It probably consists chiefly of chlorite, but this opinion is based upon a cursory examination.

All the varieties of talc merge into country rock to some extent; for instance, there are all gradations between silica rock and pure white talc. Some of the intermediate materials ("semi-talc") are difficult to distinguish from pure talc. Inclusions of partly altered country rock are numerous in the ore bodies, and some talcose fragments or nodules are found to have siliceous or calcareous cores. The thorough fracturing of most ore bodies makes it impossible to sort out all of the talc fragments from the intermingled impure material.

Localization. The distribution of the talc is graphically shown on the accompanying surface map (pl. 6), cross sections (pl. 7), and underground maps (pl. 8). It is obvious that there is no single large ore body, but instead an unknown number of small ones.

The ore controls include: (1) contacts between various rock types, (2) faults and fractures, and (3) favorable rocks, to some extent. The first might be regarded as a special case of the second, since some movement has occurred along practically all contacts in the area. In general, the contacts are more important than shears and faults within a single formation.

Talc at the White Mountain mine is not restricted to any particular rock type, but the individual kinds of talc are thus restricted. Unimportant "green talc" (chlorite?) occurs in or along dikes and sills, "black" talc is found in dark dolomitic limestone, and white talc of steatite grade is generally associated with the silica rock or massive dolomite. For this reason a silica hanging wall is favorable.

There appear to be certain areal restrictions in the distribution of the talc of this mine. No talc was found west of the western fault or north of the contact where the massive dolomite begins along the northern edge of the map area (pl. 6). In fact, only small stringers of talc have been found anywhere in the massive dolomite that partly encircles the productive area, and this dolomite might be classed as unproductive except for the fact that a mile away it contains some of the talc bodies at the Florence mine.

No talc was observed in otherwise unaltered rocks. There is invariably other evidence of hydrothermal activity besides the presence of talc. The hard black, unaltered portions of the flinty dolomitic limestone are barren, but this same formation in some places has been altered to a paler material containing talc. The silica rock also is commonly altered, friable, and pulverent where talc is found.

Principal Ore Zones. The geologic map (pl. 6) shows that in the broadest sense there are two talc-bearing areas at the mine. The first is a large islandlike mass that occupies the center of the terrain shown in plate 6; it consists essentially of flinty dolomitic limestone, and it is virtually surrounded by massive dolomite. This is the main producing area. The second, to the northeast, is a small counterpart of the first; it consists of the same flinty dolomitic limestone, and is partially surrounded by the massive dolomite. The following descriptions apply to the larger of the two areas.

The ore so far discovered in the main producing area occurs in two general zones. The first, the peripheral zone, skirts the outline of the limestone island at or near the contact with the massive dolomite. The second, the central zone, has not been extensively explored and may be more apparent than real. Seemingly it crosses part of the island diagonally at or near the central fault and dike but only the two ends of the central zone have been opened by mine workings.

The ore bodies of the peripheral zone are flat or gently dipping, somewhat fragmental masses of talc and include country rock and semi-talc. The talc body that is south and west of the glory hole is over 160 feet long, 60 feet wide in horizontal plane, and locally 12 feet thick. The one that is alongside and west of the "Big Room" is narrower, but is about 200 feet long. Both of these ore bodies are associated with contacts between silica rock and flinty dolomitic limestone or between silica rock and massive dolomite (see pls. 6, 7 and 8). The other talc bodies now exposed in the peripheral zone are much smaller lenses and irregular masses.

The talc of the central zone has favored the margins of the central dike and the faults associated with the dike. One of these faults, the "Black Wall" is a westward-dipping fracture that in places separates black dolomitic limestone from white silica rock. The dark dolomitic limestone is partly altered to "black" talc, which has not been extensively mined. The crushed silica rock has locally been converted to white talc of steatite grade, ranging from a knife edge to more than 5 feet in thickness (see pls. 7 and 8). An example of talc localized at the margin of the central dike itself is to be seen in adit no. 29, where 1 to 3 feet of moderately light-colored talc borders the dike, and where "black" talc about 1 to 6 feet thick borders both the dike and the discontinuous light-colored talc. A much greater quantity of white talc was found next to the dike in adit no. 36, probably because crushed silica rock that was highly susceptible to alteration was more abundant here.

As might be expected, the largest talc bodies so far discovered are at or near the juncture of the peripheral and the central zones. The most extensively mined area is near the glory hole and "Big Room" where the central dike and the "Black Wall" fault converge, owing to a difference in dip, and at the same time approach the massive dolomite contact. The presence of abundant silica rock makes the situation completely favorable. Extensive mining and subsequent caving have made it impossible to determine the exact size and shape of the talc masses in this vicinity, and evidently there are no geological records relating to the old workings.

Most of the above-mentioned geological factors also apply to the occurrence of talc in adit no. 36. Again there is the central dike, the borders of which acted as loci of shearing and hydrothermal replacement, and plentiful silica rock, and the massive dolomite contact is nearby. Considerable talc was found here, although not as much as near the glory hole.

The basal part of the mantle in the vicinity of the talc ore bodies locally contains abundant talc fragments that have remained as an insoluble residue where the dolomite has been removed in solution. The creep of the mantle has found the least frictional resistance in this talcose zone and has produced small shear planes in the mantle parallel with the surface of the ground. At several localities quantities of talc in the mantle were thought to indicate the presence of underlying ore deposits. Adits driven beneath showed the bedrock to be barren. It is probable, however, that talc bodies yet to be discovered are completely covered by the mantle.

Florence Mine[25]

The Florence mine was studied by L. A. Wright and B. M. Page during 3 days in September 1942. This property is below and to the east of the White Mountain mine, in the Inyo Range (fig. 3). It is in the same canyon as the White Mountain mine, and is reached by the same road from Keeler. The Florence talc deposit is about 5,500 feet above sea level, and is in a piñon-covered terrain without a water supply. Water is hauled from the White Mountain mine.

The Florence mine is owned by the Sierra Talc Company of Los Angeles, and is operated for the company by Mr. William Bonham.

Workings, Operation, and Production. In 1942, development consisted of some 40 cuts, adits, and shafts scattered over an area about 0.6 mile long and 0.1 mile wide along both sides of a canyon. The accompanying map, plate 9, shows only the site of recent mining on the south side of the canyon. This was the only place where workings extended to any depth, and the only place where recent stoping had been done. The main adit here is about 80 feet long, reaches a depth of 54 feet, and is in talc throughout.

[25] This section has been compiled from a report by Lauren A. Wright and Ben M. Page.

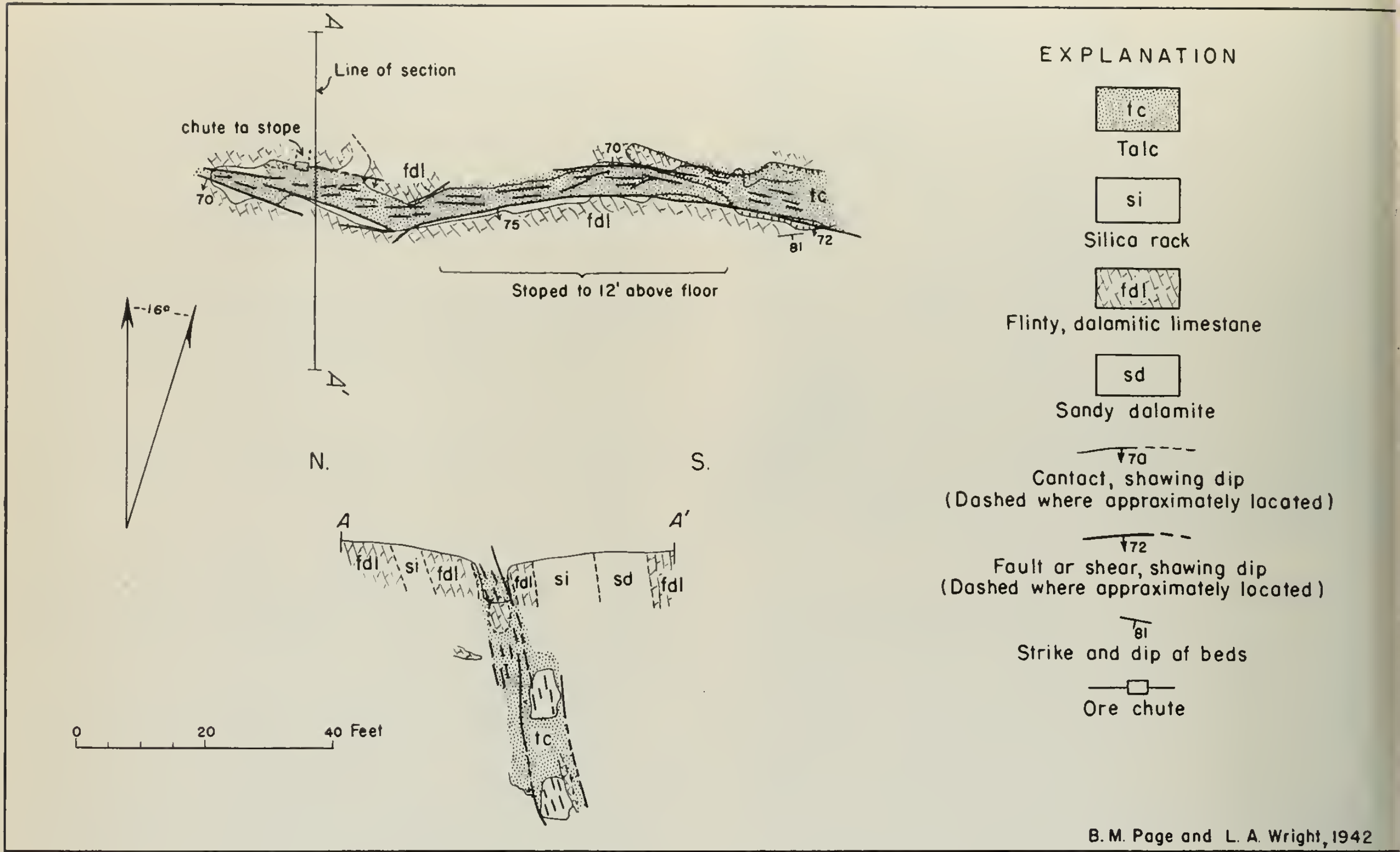


Figure 19. Map and cross-section of the main adit, South Deposit, Florence mine.

At the time of the writer's visit to the mine, the main adit was not being worked. Since 1942, mining has shifted to the north side of the canyon beyond the area shown in plate 9, and talc of better quality has been produced.[26]

Some of the older workings, now partly caved and abandoned, must have furnished at least a few hundred tons of talc. The mine's total output is not readily ascertained, but probably during its existence of about 10 years it has produced only 1,000 to 3,000 tons. At the time of the geological study, production was negligible because the mining crew was needed at the White Mountain mine. The operation has been sporadic, but at times has yielded 50 tons or more of talc a week.

Although attempts have been made to hand sort the ore, this is only partly successful because the material falls to pieces during mining and is therefore too fine to be sorted.

The Sierra Talc Company, owner of the mine, mills the talc at Keeler and sells it for non-steatite purposes.

General Geology. The rocks at the Florence mine are similar to those of the White Mountain mine, and may in part be identical.

The most striking geological features are long east-west slivers of dark dolomitic limestone, locally flinty. They are embedded in an immense area of massive dolomite that is partly a coarse marble. At least a part of the massive dolomite originated as an alteration of the darker stratified rock, but in many places the two types are now separated by faults.

[26] Booth, Otis, oral communication.

As at the White Mountain mine, a rather thick mantle covers some of the terrain, which may contain undiscovered talc deposits.

The South Deposit. The southern Florence workings (pl. 9) are in the largest sliver of flinty dolomitic limestone. This sliver is 250 feet wide in one place, but in a distance of 1,000 feet along the strike it dwindles to 8 feet in width. Its total length is well over 1,600 feet and may be more than a mile. This elongated sliver is locally or perhaps entirely separated from adjacent massive dolomite by southward-dipping faults.

Some of the talc occurs in small quantities adjacent to a mass of silica rock and some is scattered within white, altered, powdery parts of the flinty dolomitic limestone. The bulk of the talc, however, composes a tabular body along a steep south-dipping fault (see fig. 19). This fault, where exposed in the main adit, lies well within the flinty dolomitic limestone sliver; but farther west it seemingly coincides with one edge of the sliver, which is bordered by massive dolomite.

The south deposit where best exposed is from 1 to 2 feet thick. In places it is bounded by distinct walls, but elsewhere there are false walls, and the true thickness has not everywhere been determined. The measurable length of the talc body is 105 feet, but talcose material occurs discontinuously for 900 feet along the strike. The westernmost showing of talc is about 450 feet beyond the map area of figure 6. It is not known how much, if any, of the talc in this deposit is steatite; much of it definitely contains too much lime.

Other Talc Deposits. Several talc deposits at the Florence mine occur beyond the area shown in plate 9, and were not mapped by the writer.

On the north side of the canyon, directly across from the south deposit, a new prospect was being opened up in 1942. A 4-foot thickness of light-gray talc was exposed here in a 12-foot adit. The talc is at or near the contact between light-colored massive dolomite and an included sliver of dark-gray dolomitic limestone. Talc showings appear discontinuously on the surface for a distance of 180 feet to the west.

Farther west a similar occurrence of talc is exposed at intervals for a distance of 75 feet. There is only one small excavation here.

Still farther west, well up on the north side of the canyon, is an altered zone in massive dolomite. This altered zone is 5 to 30 feet thick, about 200 feet long, and contains streaks and lumps of talc that comprise 20 percent to 50 percent of the zone. An abandoned open cut 35 by 20 feet and several other workings are in this zone.

A more extensively mined deposit is near the western border of the Florence area. Caved adits, now wholly inaccessible, have apparently penetrated a sliver of dark flinty (?) dolomitic limestone, surrounded by light-colored massive dolomite which contains some silica rock. Near the caved portal of the workings a 6-foot thickness of moderately dark talc occurs between a hanging wall of silica rock and a footwall of dark dolomitic limestone. Nearby the latter rock contains an altered zone 6 to 10 feet thick, of which about 20 percent is talc. Perhaps the workings that are now caved explored still other talc deposits.

Below some of the deposits described above, near the level of the road up the canyon, is a discontinuous bleached zone nearly 500 feet long. Much of the zone is only 1 foot thick, but it ranges to 10 feet thick. In places it contains streaks of talc aggregating from ½ foot to 3 feet in thicknesses, but in other places it is barren. This bleached zone is locally near the edge of a silica mass, but elsewhere occurs near the contact between pale massive dolomite and a sliver of dark flinty dolomitic limestone. It is penetrated by 8 abandoned small cuts.

In several places small veinlike streaks of talc were noticed in shears and joints within the massive dolomite, in some cases branching complexly. These small veins are not workable.

The Talc. The talc at the Florence mine ranges in color from medium gray or tan to gray white or greenish white. The latter is the most prevalent tint in the talc of the south deposit shown in plate 9.

The talc is universally fine-grained and lacking in true foliation or fibrous character. For the most part it has been crushed and sheared to a marked degree and therefore occurs chiefly in a fragmental state. The fragments of talc in the south deposit are partly separated from one another by thin calcite films, which may have been deposited by surface waters. Other megascopic impurities include scattered small calcite crystals and, less commonly, specks of pyrite and limonite.

The Geological Survey submitted over 100 pounds of talc from the south deposit to the Bureau of Mines for testing. The sample (U.S.G.S. no. 39) showed 3.44 percent CaO and 0.86 percent Fe_2O_3, and therefore cannot be considered steatite and is not sold as such. However, this single analysis does not condemn the whole deposit, which has not been systematically tested.

Some of the talc from deposits on the north side of the canyon is said to be of higher quality, the CaO content ranging from 1.26 percent to 3.0 percent.[27] The Sierra Talc Company has kindly provided an analysis of such material, which shows only 1.14 percent CaO, 1.26 percent Fe_2O_3, and 1.72 percent Al_2O_3. Therefore, some of the talc is presumably of steatite grade. However, it is used in cosmetics and nonradioelectric ceramics.

Trinity Talc Mine

The Trinity mine is between Keeler and Darwin, about 1 mile southwest of the Talc City mine. In the past it has been known as the Pacific Coast Talc mine [28] and as the Angelus Talcs. Formerly owned by the Pacific Coast Talc Company, it has been acquired by the Sierra Talc Company of Los Angeles. During the last decade or two it was a major producer. The following data were obtained by the writer during a cursory examination May 1, 1942, at which time the mine was idle although still partly equipped.

The geological setting is similar to that of the Talc City mine. All the talc observed is in the massive dolomite that extends uninterrupted to Talc City, and as at the Talc City mine, there is at least one mass of silica rock within the dolomite area. Perhaps the silica rock is the "igneous intrusive" mentioned by Tucker and Sampson.[29] The talc observed at the Trinity does not occur along contacts, however; it apparently was formed by the alteration of massive dolomite only. The ore bodies are lenses that lie in several attitudes, and which were probably localized by minor fractures. One lens must have been at least 40 feet long and 25 feet thick, judging by the size of the main excavation. The talc seems physically identical with that of Talc City, being pale green, fine-grained, and rather massive. It is believed to have about the same composition, and officials of the Sierra Talc Company affirm that it is of steatite grade.

The workings consist of several adits, a glory hole, a gently inclined shaft perhaps 100 feet long, a vertical shaft more than 50 feet deep, and several drifts, crosscuts, and stopes.

Only small remnants of talc are now visible. Undoubtedly undiscovered ore bodies exist, but their disclosure is not likely without the drilling of prospect holes. An area that might be explored is just south of the inclined shaft at the dolomite-silica rock contact.

A more careful study of the Trinity mine should be undertaken to determine its potentialities.

East End Mine and Bob Cat Claims

The East End mine is an inactive and largely worked-out property less than a mile northeast of the Talc City mine, about 6 miles northwest of Darwin. The East End deposit is reached by a road from the Lone Pine-Death Valley highway, and was examined by Lauren A. Wright and the writer December 8, 1942. It was operated by the Sierra Talc Company some years ago, and called by them the East End. It has subsequently been relocated as part of the Bob Cat claims by R. H. Bagley.

[27] Mulryan, Henry, oral communication.
[28] Tucker, W. B., and Sampson, R. J., California Div. Mines Rept. 34, pp. 492-495, 1938.
[29] Op. cit., p. 493.

The main deposit contains pale-green, crudely foliated, fine-grained talc. It occurs as a lens between massive dolomite and a gray, platy limestone from which the dolomite was derived. This lens, largely mined out, is penetrated by a 60-foot inclined shaft with an adit meeting the shaft at the 30-foot level. Between this adit level and a drift at the bottom of the shaft, the talc has been stoped for a lateral distance of more than 100 feet, the stopes being 5 to 15 feet wide. Most remnants of talc around the margins of the stopes are very thin, from a fraction of an inch to 2 feet in thickness. From the 60-foot level an inclined winze 35 feet long follows the same ore body, which is ½ foot to 5 feet thick. At the bottom of the winze a 70-foot drift blocks out part of the body below the 60-foot level, but in this drift the talc is thin and pinches to 1 foot at both ends of the drift.

Within 100 feet of the main deposit, to the west and southwest, a cut reveals a talcose zone in a residual patch of stratified dolomite and limestone that is surrounded by massive dolomite. This talc, which is not an extension of the main body, is mainly very dark and hopelessly intercalated with country rock. Nearby, a 20-foot shaft exposes discontinuous talc 1 foot to 4 feet thick.

On the other side of the main deposit, 100 to 200 feet to the northeast, there are two pits about 70 feet apart. One pit shows 6 feet of probable steatite and the other shows 4 feet of similar talc, but nearly continuous exposures of dolomite lie between the two pits. Thus, it is unlikely that a large talc body extends from one pit to the other.

Still farther north of the main East End workings, the Bob Cat claims include a 20-foot shaft and two pits in separate (?) talc bodies 1 foot to 5 feet thick, in massive dolomite with remnants of original stratified sediments.

No samples were taken, but the proximity of the Talc City mine together with superficial resemblance of the ore and identical occurrence suggest that the talc is of steatite grade.

Frisco Talc Mine

The Frisco mine was examined by Lauren A. Wright and the author. The geology was mapped mainly by Wright during two days in December 1942. The property is not more than a mile southwest of the Talc City mine; it is 6 miles northwest of Darwin, and may be reached by good roads from Darwin or from Lone Pine and Keeler.

On the Frisco no. 2 claim, a 65-foot shaft and short drift were made in 1942 by the Sierra Talc Company of Los Angeles. The shaft is between two sets of old prospects and workings made by the same company some years ago, but the old developments will not be fully treated in this report. The old operations produced "green talc" (chlorite, apparently) said to contain more than 20 percent alumina. After a number of years of inactivity, exploration was resumed in 1942, and the recent shaft revealed talc of steatite grade. In July 1942, 100 tons of steatite was shipped from the Frisco. The next month only 22 tons was produced, and altogether the small mine had not yielded more than 300 tons of steatite by the end of 1942.

The rocks are identical with those of the Talc City mine. Their distribution is shown in plate 10.

Limestone, well stratified, appears in two neighboring, strangely shaped patches. The limestone dips steeply westward, and the grayish strata project somewhat above the ground like thick shingles on edge.

Massive dolomite is the most prevalent rock. Its relationship to the stratified limestone shows clearly that it has been altered from the limestone by hydrothermal solutions. The dolomite is pale gray to nearly black, free of fossils and stratification, and forms numerous rough-surfaced outcrops.

Dikes of pale felsite (rhyolite?) are found near the mine. One dike is just west of the shaft, and others lie to the east beyond the map area. Being hydrothermally altered, the felsite does not crop out well. Much of it has been altered to chlorite (?).

Silica rock which resembles quartzite (fig. 7) occurs underground in the shaft and drift made in 1942. The steatite talc is associated with this silica rock and has been derived from it.

The main masses of limestone, the felsite dike, and the strip of silica rock all converge toward a common point east of the 1942 shaft.

As shown in pl. 10, the talc is near a felsite dike and close to the edge of the limestone area, but shows greatest affinity for the dolomite and a steeply dipping strip of silica rock.

The talc body appears to be somewhat lenticular in shape. In the shaft it is interrupted by numerous inclusions of siliceous rock, and it is probably likewise interrupted along the strike. The ore is pale, blocky, fine-grained, and soft. It is of steatite quality, as shown by its acceptance by the steatite industry. The talc extends down the shaft 50 feet, but further downward prolongation is rather doubtful (pl. 10). Lateral development may be encouraging, however, and if so, the downward exploration may be resumed later. On the surface, intermittent talc showings extend more than 100 feet along the strike and the width of the ore body is about 10 feet.

Massive green chlorite (?) occurs abundantly as a replacement of parts of the felsite dikes at the Frisco mine. The chlorite (?), which was once produced as "green talc," was not being mined in 1942. About 1946 the mining of the green material was resumed, and the mineral is now sold under the name "Sierralite" for use in cordierite ceramic bodies. It is said to have the following composition [30]:

	Percent		Percent
SiO_2	36.24	CaO	1.47
Fe_2O_3	1.19	Ign. loss (H_2O)	12.19
Al_2O_3	23.56	CO_2	0.86
MgO	23.39	Moisture	0.18
Alkalis	0.35		
			99.43

Victory Talc Mine

The small Victory mine was examined by Lauren A. Wright and the author in December 1942, when mine development was in progress. The property is 7½ miles northwest of Darwin and 15 miles southeast of Keeler, from which it is reached by dirt road. The owners are Mrs. Edith Lockhart and George Koest of Darwin, California, but the lessees and operators are A. C. Palmer and Raymond Palmer of Lone Pine. Two men were working on the premises in December 1942.

[30] Analysis kindly furnished by Mr. Henry Mulryan.

The talc is only 3 to 5 feet wide on the surface of the ground, and barren trenches across its projected path limit the length on the surface of the ground to 50 feet along the strike. The country rock is gray massive dolomite of the type found at the Talc City mine a mile away. There is no visible structural control of the ore.

The talc crops out on a hillside, and the ore was followed downward by a shaft about 25 feet deep. A 170-foot adit driven about 50 feet lower than the shaft collar had failed to intersect ore in 1942, although it seemingly passed under the shaft. It was later learned that a raise reached the talc 12 or 18 feet below the bottom of the shaft. The quality of the talc is probably good, judging from the resemblance to nearby steatite deposits.

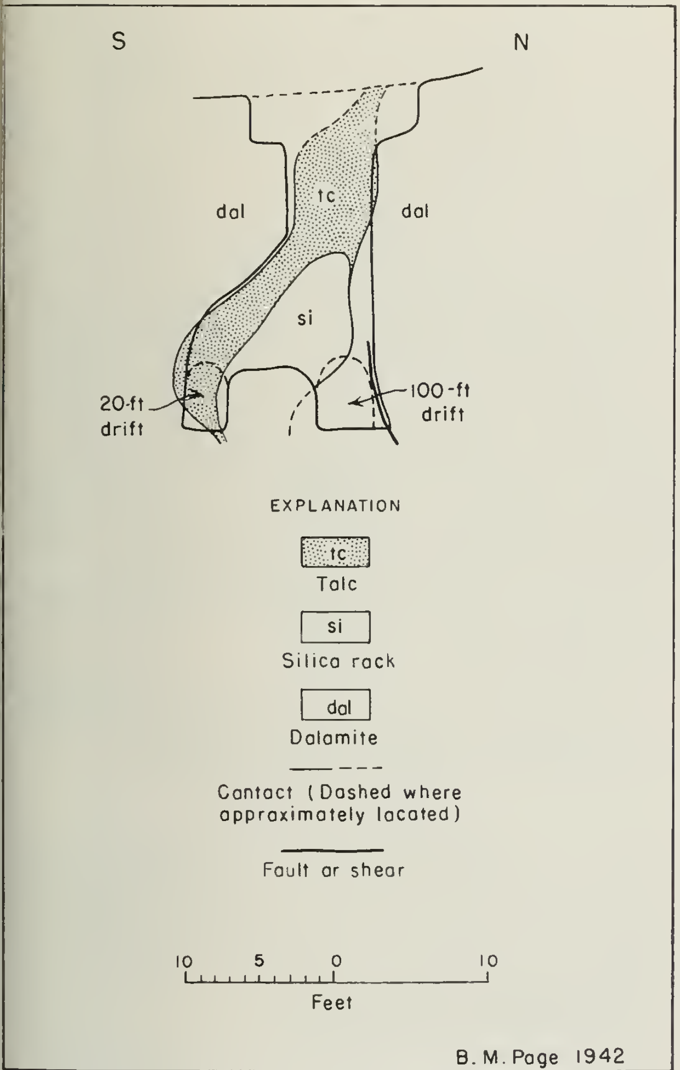


Figure 20. Cross-section, Viking talc mine.

Viking Talc Mine

The small Viking talc mine is 16 miles southeast of Keeler and 10 miles northwest of Darwin, and just north of the highway to Death Valley. The owner is Mrs. Edith Lockhart of Darwin, who had leased the property to Mr. Wilcox in April 1942. At that time one man was employed, and no ore was being produced.

There is a 20-foot shaft on the premises with two drifts at the bottom, one extending 20 feet and the other about 100 feet eastward. These workings are partly in talc and partly in country rock. On the surface 80 feet east of the shaft there are a 30-foot trench and a short adit that exposes 1 foot to 5 feet of talc; 15 feet farther east, a pit exposes 2 to 3 feet of talc in stringers.

The rocks are similar to those at other talc mines in this region. Light-gray to black massive dolomite predominates, but within it is an intermittent, apparently steeply dipping strip of silica rock that resembles quartzite. The talc occurs sporadically and irregularly along this siliceous material (see accompanying cross section, fig. 20), and probably was derived from it.

The talc is white, opaque, blocky, and soft. It has some superficial orange-red stains (which are commonplace in the district) and a few limonite cubes. No sample was taken, but nearly all the talc in the district is of steatite grade except where obvious impurities are too abundant.

White Swan Talc Mine

The White Swan mine or prospect is perhaps a mile west of the Viking property and is easily reached by road from the Lone Pine-Keeler-Death Valley highway. It is 15 miles southeast of Keeler and 11 miles northwest of Darwin. The writer was there for only a few hours in April 1942. The owner is Mrs. Edna M. Towers, 316 West Imperial Highway, Los Angeles. The former lessee was a Mr. Wilcox, but no one worked the mine during 1942.

Development includes two shafts less than 30 feet deep, partly in talc, and two or three adits less than 50 feet long in separate talc showings. The main working, however, is a branching adit shown in figure 21. One branch is over 400 feet long and mostly barren, while the other is about 50 feet and was chiefly in ore. The short branch was expanded into a stope which must have yielded 400 tons of talc. Total production cannot have exceeded 700 tons.

The country rock and ore are superficially identical with those at Talc City. The country rock is massive gray dolomite, and the talc is fine-grained, blocky, and pale green. The ore occurs in frayed lenses and streaks, which dip steeply. The largest lens (see fig. 21) is visible for 125 feet along the strike but is only 1 foot to 5 feet thick. It has been mined up and down the dip about 30 to 40 feet. The continuation of the workable portion may be downward and to the west. The talc has been localized by minor fractures rather than by contacts between rock types; it is chiefly bounded by dolomite, although some silica rock was noted nearby.

Lakeview Talc Mine

The Lakeview mine is idle, having seemingly been worked out. It is $2\frac{1}{2}$ miles north-northwest of Keeler, near the foot of the Inyo Range but about 4,400 feet above sea level. The loading bin is reached by road from Lone Pine or Keeler, and the mine itself is 100 yards or so above the road on a steep hillside.

A. C. Palmer and Raymond Palmer of Lone Pine were the operators of the property during its chief activity, and probably produced between 1,000 and 3,000 tons of talc. The following data were collected by L. A. Wright and the writer in December 1942.

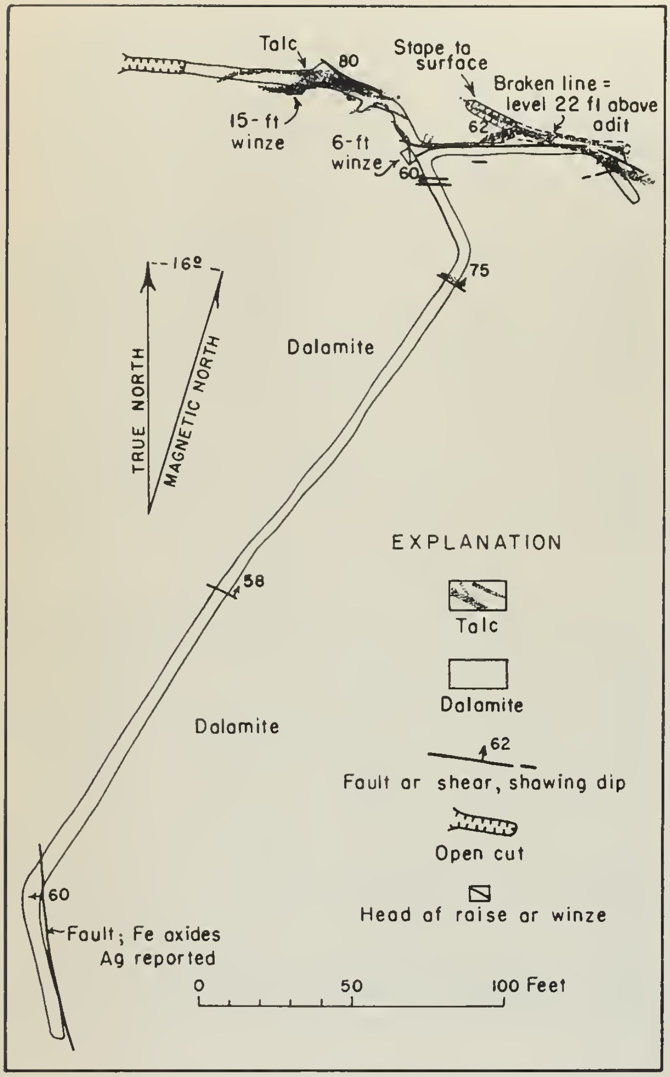


FIGURE 21. Cross-section, White Swan talc mine.

A vertical shaft 30 to 50 feet deep connects with one visible level at the bottom. From this level there are two principal stopes that almost reach the surface. They are close together, steep, and en echelon; one is about 25 feet long and the other is 45 feet. Both stopes are 3 to 10 feet wide and 2 to 40 feet high. The floors are concealed, but at one end of the pair of stopes the ore pinches out and the other end is very near the surface of the ground, owing to the steepness of the hillside.

One stope is in a steep lens of talc between quartzite and stratified gray dolomite or limestone. Dark talc occurs near the latter, and white talc near the quartzite. The other stope is along a steeply dipping talcose sliver of dolomite or limestone that is enclosed in a diabase dike. The diabase itself is not talcose. The ore remnants appear to be of high quality, and are probably steatite, but they were not sampled by the Survey.

Blue Stone Talc Mine

The Blue Stone mine is small, inactive, unequipped, and perhaps largely worked out, but the remaining talc is probably of steatite quality. The property is on the side of a canyon on the west side of the Inyo Range, 10 miles from Independence, and is reached by dirt road via Mazurka Canyon (see Mt. Whitney quadrangle). The railroad at Kearsarge is 9 miles away by road.

Walter Sorenson of Lone Pine, California, is the owner, and W. H. Huntley of Bigpine was a recent lessee. Mr. Huntley accompanied Lauren A. Wright and the writer during a 3-hour examination of the mine November 30, 1942.

Talc was noticed here by Goodyear[31] in the 1880's.

The predominant rock is thick-bedded, dark-gray Devonian (?) limestone containing discontinuous thin streaks of flint. The strata dip steeply but uniformly westward. Interbedded with the limestone is a quartzite member possibly 20 to 60 feet thick, which forms the footwall of the main ore body. The talc occurs within the limestone, from which it was derived.

The main ore body is nearly mined out, its site being outlined by a steep lenticular stope that measures about 40 by 40 by 10 feet along its principal axes. The stope, which yielded the entire 800-ton output of the mine, connects directly with the surface of the ground. From the lower end of the stope, a chute leads to an adit about 50 feet below. This adit, which was driven in from the mountainside, is 100 to 200 feet long, and although it passes beneath the ore body and follows the controlling limestone-quartzite contact, it does not intersect any ore. The downward limit of the stoped body is thus quite definite, and the longitudinal limits are implied by the fact that the ore pinches to 12 or 18 inches at each end of the stope.

Other intermittent talc showings 1 foot to 2 feet wide occur on the surface north of the main deposit, but are not visibly connected with it. About a third of a mile south of the main ore body, talc as much as 2 feet in width is exposed for 50 feet, partly in two small adits. This talc is bounded by flinty limestone, with no quartzite, but is not far off strike from the main body. There are other small, discontinuous showings of talc.

The ore at the Blue Stone is mainly mottled gray, soft, blocky, massive talc. The Bureau of Mines kindly reported as follows on a sample:

> U.S.G.S. No. 65—Blue Stone mine. Collected by Wright and Page, 11/30/42 (about 15 lbs.). CaO, 0.10%; Fe_2O_3, 0.42%; color fired 2300° F, white; mineral impurities, very low; abrasion, soft; Tuscaloosa laboratory rating, O.K.

The material is probably of steatite grade.

Willow Creek Talc Mine

This mine, although small, has reportedly yielded talc of steatite grade. It is now apparently worked out, having produced a probable total of about 1,000 tons, mostly within a year's time. Lauren A. Wright and the writer gathered the following data during May 1942, near the termination of mine operations.

The deposit is on the steep south side of the valley of Willow Creek, which runs through the east flank of the Inyo Range and empties into the north end of Saline Valley. The Willow Creek mine is reached from Bigpine by a poor dirt road, the same one which leads to the White Eagle mine. The approximate longitude and latitude are: 117° 56′ 15″ west, and 36° 50′ 40″ north (see Ballarat quadrangle). The owner is Emil Carlson of Bigpine, California. Almost all the development and mining have been done by a lessee, G. P. Rogers of Bigpine.

[31] Goodyear, W. A., California Div. Mines Rept. 8, p. 268, 1888.

The geology is unusual in that the mine appears to be in a landslide or an incipient landslide. There are large topographic benches farther up the mountainside, and the mine workings are in a highly fractured, extremely unstable rock mass with many gaping cracks. The most prevalent rock is granite. Within it are pendants of white limestone, and along the edge of one pendant a lens of talc occurs, as shown in the accompanying figure 22, which indicates the outline of the ore prior to mining. The talc must have been at least 20 feet thick at its widest part, but it narrows rapidly along the strike. It lies transversely across a ridge and does not appear at lower levels in the ravines on either side of the ridge.

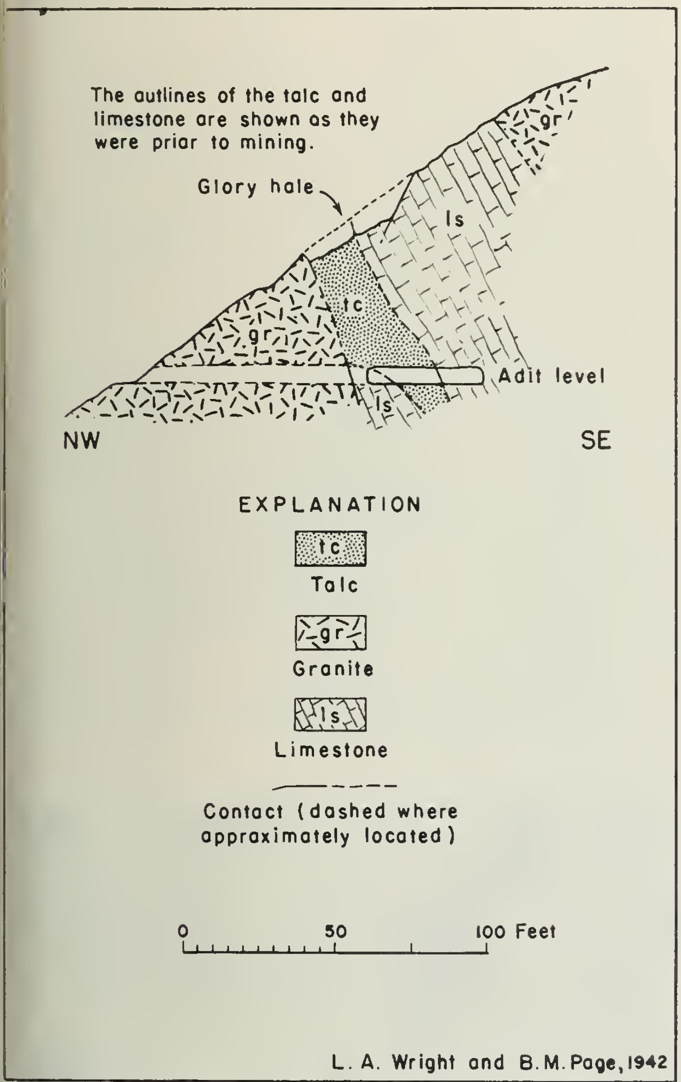


Figure 22. Cross-section, Willow Creek talc mine.

The deposit was mined mainly from two adits which tapped a glory hole. The ground was initially thoroughly fractured by natural movement down the steep mountainside, and it was further disturbed by the mining. The lower adit was kept open with great difficulty and considerable danger and expense.

The talc is gray-white, fine-grained, and blocky, outwardly resembling the associated limestone. Officials of the Sierra Talc Company, which purchased the ore, say that it is of steatite grade.[32] There is probably additional talc somewhere on the mountainside above, if the Willow Creek deposit is actually in a landslide, but unfortunately the slope is partly covered by other slides.

White Eagle Talc Mine

Geologically, the White Eagle mine is of interest because much of the talc has been derived from the alteration of granite. It is doubtful, however, that the talc is of steatite quality.

At the outset of World War II, the newly developed White Eagle mine was considered to be a potential source of steatite. Subsequently, either because of difficulties in sorting out impurities, or because of variability in the quality of the deposit, a controversy arose as to the utility of the talc. A leading radioceramics manufacturer tentatively approved the material, but later condemned a carload shipment. Some large samples have given unsatisfactory analyses, while some small samples appear to be of steatite quality. If the talc of the White Eagle mine can be used for steatite, it represents a large reserve.

Lauren A. Wright and the author studied the mine during May, 1942. The origin of the talc has recently been discussed by Wright.[33]

The White Eagle mine is on the very steep eastern slope of the Inyo Range overlooking Saline Valley, Inyo County, Calif., 1 mile south of Willow Creek. The workings are about 3,600 feet in elevation, the ore bin at the bottom of the aerial tram is approximately 2,500 feet, and the main camp (near the mouth of Willow Creek) is at an elevation of around 2,300 feet above sea level. Soil and vegetation are scanty along the arid eastern side of the Inyo Range.

The camp is reached by a circuitous route from the Owens Valley highway. Automobiles must enter Saline Valley at the north end, following the Bigpine-Waucoba Canyon road. The road is partly steep, rough, tortuous, and generally unsatisfactory. From the foot of the mountain the mine is accessible only by a trail about half a mile in length.

History, Operation, and Production. Mr. Elmer Oaks of Bigpine is the discoverer of the talc deposit. The property was not exploited until 1941 when it was leased to Mr. Wright Huntley of Bigpine. The mine was bought by the Sierra Talc Company in 1945, but it is still leased to Mr. Huntley.

Initial development of the property included the driving of three short adits one of which is in talc throughout. At the site of the latter adit, an open cut was made. Talc is mined from this cut, which has been enlarged and benched. After being hand-sorted, the talc is taken to the foot of the mountain by means of a 2,000-foot jig-back aerial tram.

During the first year of production (1941-42) the mine was inactive a good part of the time. An effort was being made to produce talc of steatite grade, but sorting of the ore was difficult and only partly successful. About 1,570 tons of talc was produced in 1941, beginning in August of that year, but only 700 tons was shipped in the first 5 months of 1942. Altogether, 2,270 tons had been

[32] Booth, Otis, oral communication.
[33] Wright, L. A., White Eagle talc deposit: an example of steatization of granite: (abst) Geol. Soc. America Bull., vol. 59, p. 1385, 1948.

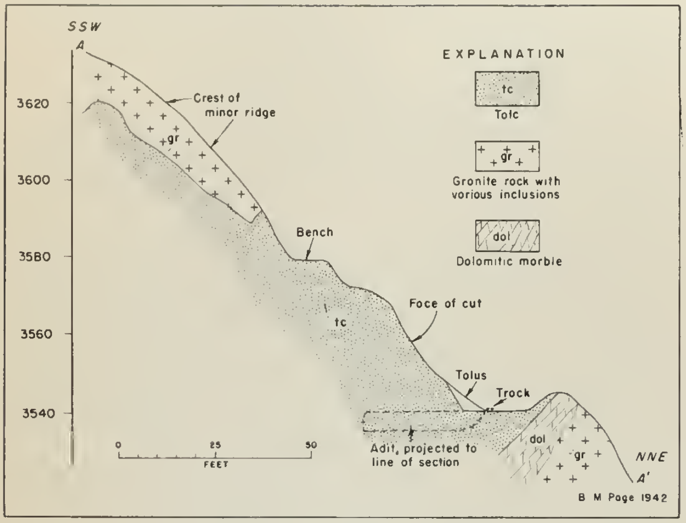


FIGURE 23. Geologic section at main quarry, White Eagle mine.

produced up to the time of this investigation. The talc is trucked 137 miles to the Sierra Talc Company mill at Keeler.

The Rocks and Geologic Structure. The east slope of the Inyo Range is an eroded fault scarp, steep and almost devoid of soil. The rocks near the base of the slope are sheared and crushed, but the mine itself is farther removed from the marginal fault which bounds the range, and considerable continuity was observed in the various rock units. The steepness of the escarpment has caused some landsliding, however, even at the site of the talc deposit.

The areal geology is shown on the accompanying map, plate 11.

Silica rock occurs as an elongated body. It probably is quartzite and displays faint stratification, unlike the silica rock of the Talc City mine. Possibly it has been altered to dolomite in places, as its thickness varies considerably where it is bordered on both sides by dolomitic marble.

Dolomitic marble is one of the oldest rocks at the mine. It is light, warm brown on weathered surfaces, but where freshly broken it is white to gray. Much of the dolomitic marble is sufficiently coarse that the cleavage surfaces of the constituent crystals are readily visible at a casual glance.

Granitic material (probably granite or quartz monzonite) has invaded and partly engulfed the silica rock and dolomitic marble. The granite is moderately dark gray, and contains both biotite and hornblende; the grains are small to medium in size. Numerous included slivers and blocks of dark schists and some basic igneous rocks are present within the granitic mass.

In general the rock units occur in roughly parallel bands, as seen in plan, but there is much local irregularity. the granitic rock is moderately discordant in its relations with the other rocks. The dolomitic marble appears in isolated patches as well as in continuous bands. The silica rock varies in width and terminates abruptly at both ends. The talc body likewise is not tabular nor lenticular in form. These irregularities in the areal pattern of the rocks are the result of igneous intrusion and hydrothermal alteration rather than folding, faulting, or other mechanical deformation.

Despite the lack of uniformity in detail, all of the mappable units strike nearly north-south, and in general dip westward.

Only one fault, a minor one, is shown on the map. However, the footwall of the northern portion of the talc is a distinct plane which is either a joint or a shear plane. On the whole, joints are notably abundant in this area.

The Talc. Landslide and talus material locally cover the talc, and prior to the excavation of the open cut, it appeared that there were two main deposits rather than a single large body.

In plan the talc body is "L" shaped, consisting of two contiguous segments of unequal thickness that are at right angles (see pl. 11), and which dip more or less toward one another. The lengths of the segments are respectively about 250 and 200 feet. The corresponding map widths are 38 and 95 feet, but these figures do not represent the true thicknesses. Taking into account the dip of the talc, the slope of the ground surface, and the irregularity of the granite contact, the thickness of one branch of the talc body is locally 138 feet (fig. 23) and that of the other branch is locally 46 feet.

The talc grades into dolomitic marble, granite, and silica rock, and was almost certainly formed by hydrothermal alteration of all three. It contains partly replaced inclusions of the three rock types. These inclusions are numerous and are one of the most troublesome features of the deposit. They range from less than 1 inch to more than 5 feet in diameter, and commonly resemble rounded nodules of talc. The talc composing the exterior of the nodules grades into a core of granitic rock, dolomite, or silica rock as the case may be, granitic cores probably predominating. Skill is required in sorting out these inclusions, which are usually not broken open during mining and which therefore exhibit only the talcose exterior. Their volume is of some importance but has not been accurately ascertained. Inspection of the quarry face suggests that they constitute between 5 percent and 20 percent

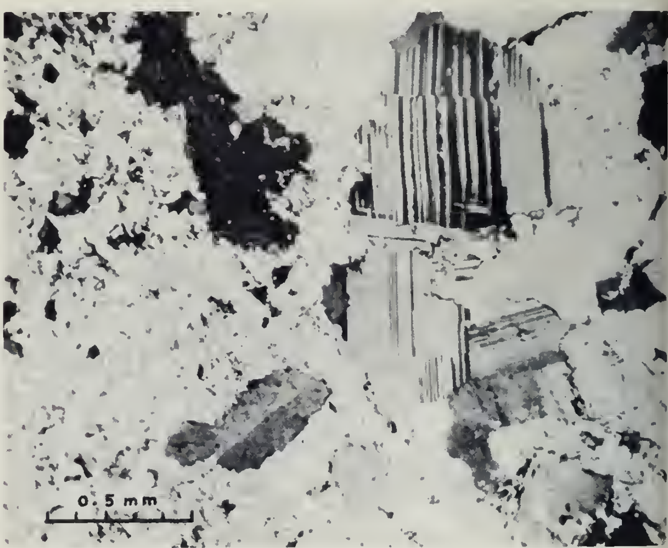


FIGURE 24. Photomicrograph of partly talcose granite rock, White Eagle mine. The rock shown is about half feldspar and half talc. Crossed nicols.

of the deposit, but the impurities may be even more abundant in the southern part of the talc body. Thin sections of partly altered rock show the transition from granitic rock to talc (fig. 24).

The talc is gray white to greenish white and is fine-grained and structureless for the most part. It is soft but brittle and is so thoroughly fractured that it breaks into rather small pieces, increasing the difficulty of sorting it by hand. In a few places the talc unmistakably exhibits a relict igneous texture inherited from the original granitic rock.

An analysis kindly provided by the Sierra Talc Company fulfills commonly accepted steatite specifications, as follows:

	Percent		Percent
SiO_2	59.76	SO_3	0.03
Al_2O_3	8.30	Na_2O	0.18
Fe_2O_3	1.10	K_2O	0.14
CaO	0.30	Loss on ignition	2.38
MgO	27.81		

Individual samples such as the foregoing do not represent the bulk of the deposit, which is variable. Some large samples show more than 2 percent Fe_2O_3 and an appreciable content of feldspar.

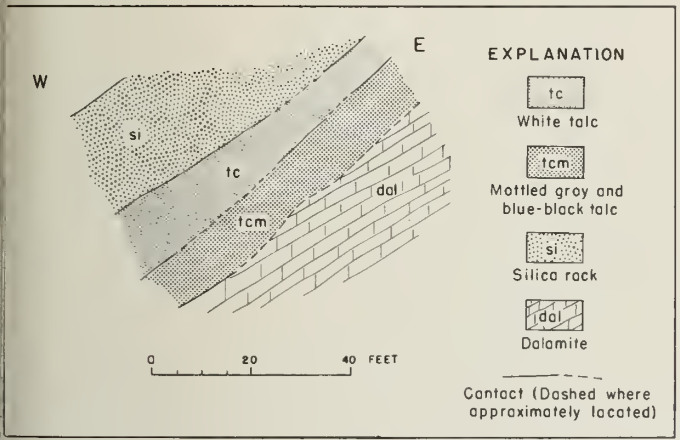


FIGURE 25. Sketch section, Eleanor talc claim.

Eleanor Talc Claim

The recently discovered Eleanor talc claim overlooks Saline Valley from a point several hundred feet up on the eastern escarpment of the Inyo Range. It is less than a mile south of the White Eagle deposit and is approached by the same road, but the final ascent from the foot of the mountain is by trail. The approximate longitude and latitude are 117° 55′ west and 36° 49′ 30″ north, juding from the Ballarat quadrangle map. G. P. Rogers of Bigpine and Frank Henderson are the owners.

In November 1942, Lauren A. Wright and the writer gathered the data of this summary. At the time there were several small cuts and a 30-foot adit.

The orebody is exposed along the surface for about 150 feet (slope distance). The adit is near the south end of the deposit. About 100 feet south of the adit continuous exposures of country rock definitely limit the ore body in that direction. The thickness of the deposit, including some "semi-talc", is about 15 feet. The vertical dimension is still unknown.

The country rock is mainly gray dolomite and dolomitic marble, stratified in places. Within this material there is a band of silica rock that is either quartzite or a hydrothermal product. The talc occurs along the under side of the siliceous rock, as shown in the accompanying sketch, figure 25. The ore is white next to the light silica rock and dark next to the blue-gray dolomite. Possibly microscopic graphite was retained during hydrothermal alteration of the dolomite. It is said that the dark color vanishes during firing.[34]

The ore is massive, blocky, soft, semi-opaque, fine-grained, and scarcely stained even at the surface of the ground. The Bureau of Mines kindly gave the following information based upon our two samples:

U.S.G.S. No. 63—Eleanor claim. White talc, collected from adit by Wright and Page, 11/29/42 (about 10 lbs.); CaO, 0.08%; Fe_2O_3, 0.95%; color fired 2,300° F, buff; mineral impurities, very low; abrasion, soft.

U.S.G.S. No. 64—Eleanor claim. Dark talc, collected from adit by Wright and Page, 11/29/42 (about 10 lbs.); CaO, 0.11%; Fe_2O_3, 0.73%; color fired 2,300° F, cream; abrasion, soft.

[34] Mulryan, Henry, oral communication.

BIBLIOGRAPHY

Anon. (Page, B. M., and Wright, L. A.), Talc in the Ganim mine, Shasta County, California: U.S. Geol. Survey Strategic Minerals Investigation, Prelim. Maps, 1943.

Anon., Talc: Ceramic Industry, vol. 32, pp. 38-40, 1939.

Dana, E. S., The system of mineralogy of James Dwight Dana, 6th ed., pp. 678-680, 1904.

Diller, J. S., Mineral Resources for 1913, U.S. Geol. Survey, pp. 153, 155, 157-160, 1914.

Engel, E. A. J., Talc and ground soapstone, *in* Industrial minerals and rocks: Am. Inst. Min. Met. Eng., pp. 1018-1041, 1949.

Goodyear, W. A., California Div. Mines Rept. 8, p. 267, 1888.

Klinefelter, T. A., Speil S., and Gottlieb S., Survey of the suitability of domestic talcs for high-frequency insulators: U.S. Bur. Mines Rept. Inv. 3804, 1945.

Knopf, Adolph, A geologic reconnaissance of the Inyo Range and the eastern slope of the Sierra Nevada, California, with a section by Kirk, Edwin, The stratigraphy of the Inyo Range: U.S. Geol. Survey Prof. Paper 110, 1918.

Ladoo, R. B., Talc and soapstone: U.S. Bur. Mines Bull. 213, pp. 111-117, 1923.

Sampson, E., Mineral Resources for 1920, Part II, U.S. Geol. Survey, pp. 203-204, 1923.

Sampson, E., Mineral Resources for 1922, U.S. Geol. Survey, pp. 81-83, 1923.

Tucker, W. B., California Div. Mines Rept. 17, pp. 300-301, 1920-21.

Tucker, W. B., California Div. Mines Rept. 22, pp. 523-524, 1926.

Tucker, W. B., and Sampson, R. J., California Div. Mines Rept. 34, pp. 492-495, 1938.

Waring, C. A., and Huguenin, E., California Div. Mines Rept. 15, pp. 126-127, 1919.

Wright, L. A., White Eagle talc deposit: an example of steatization of granite: (abst.) Geol. Soc. America Bull., vol. 59, p. 1385, 1948.

Wright, L. A., California talcs: Min. Eng., vol. 187, no. 1, pp. 122-128, 1950; also, Trans. Am. Min. Met. Eng., vol. 187, pp. 122-128, 1950.

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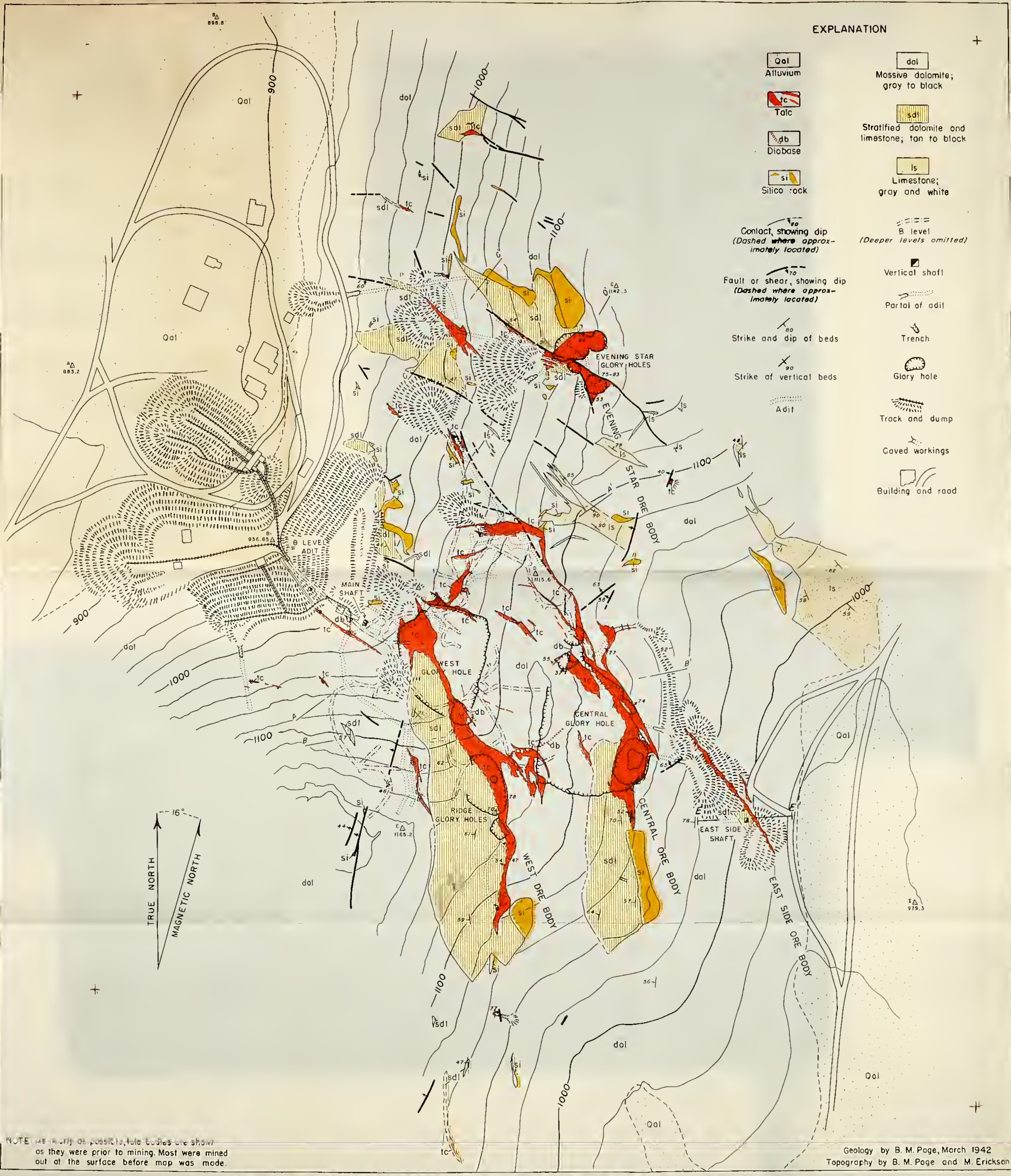


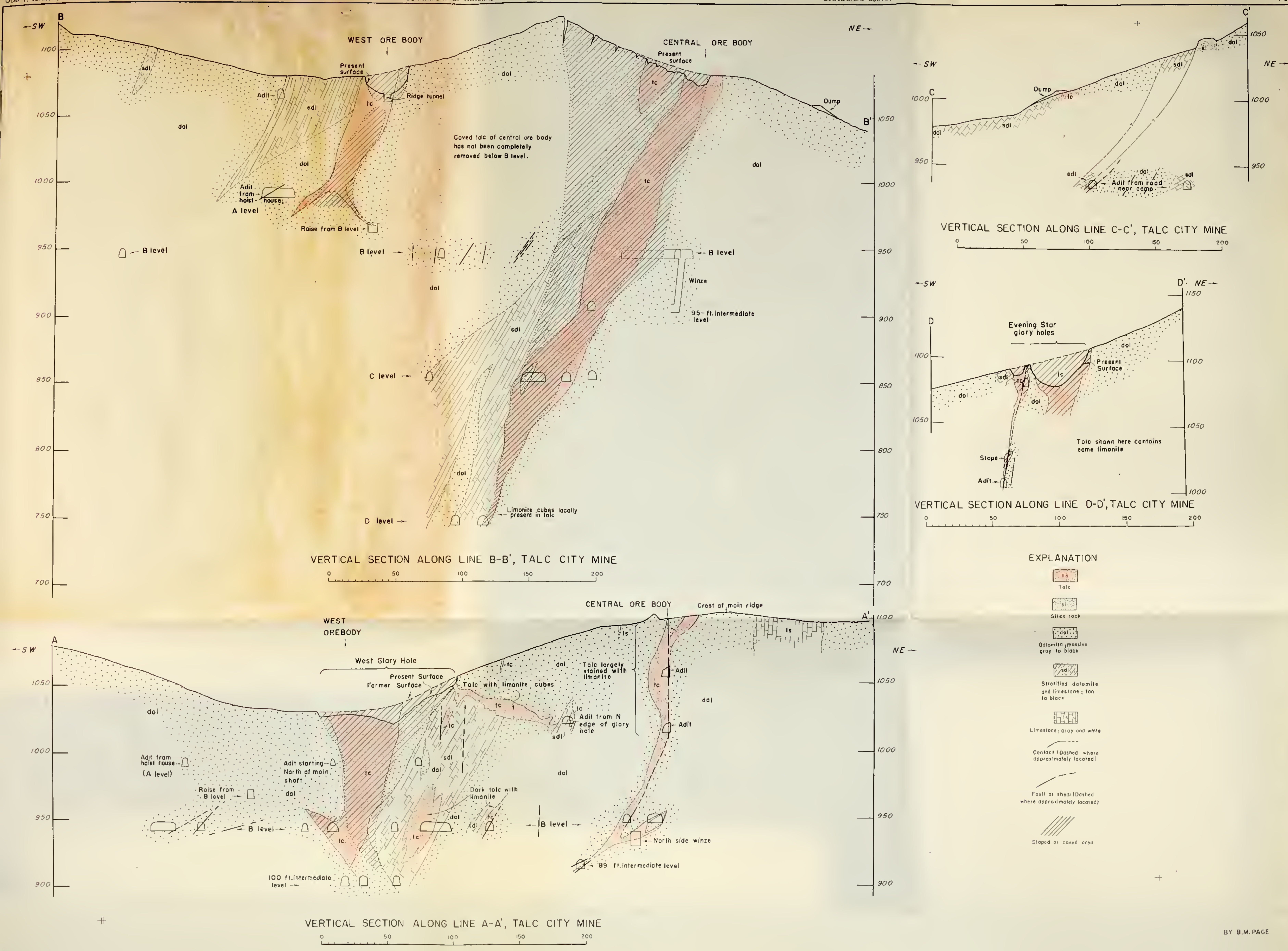
SURFACE GEOLOGY OF THE TALC CITY MINE, INYO COUNTY, CALIFORNIA

100 50 0 100 200 300 FEET

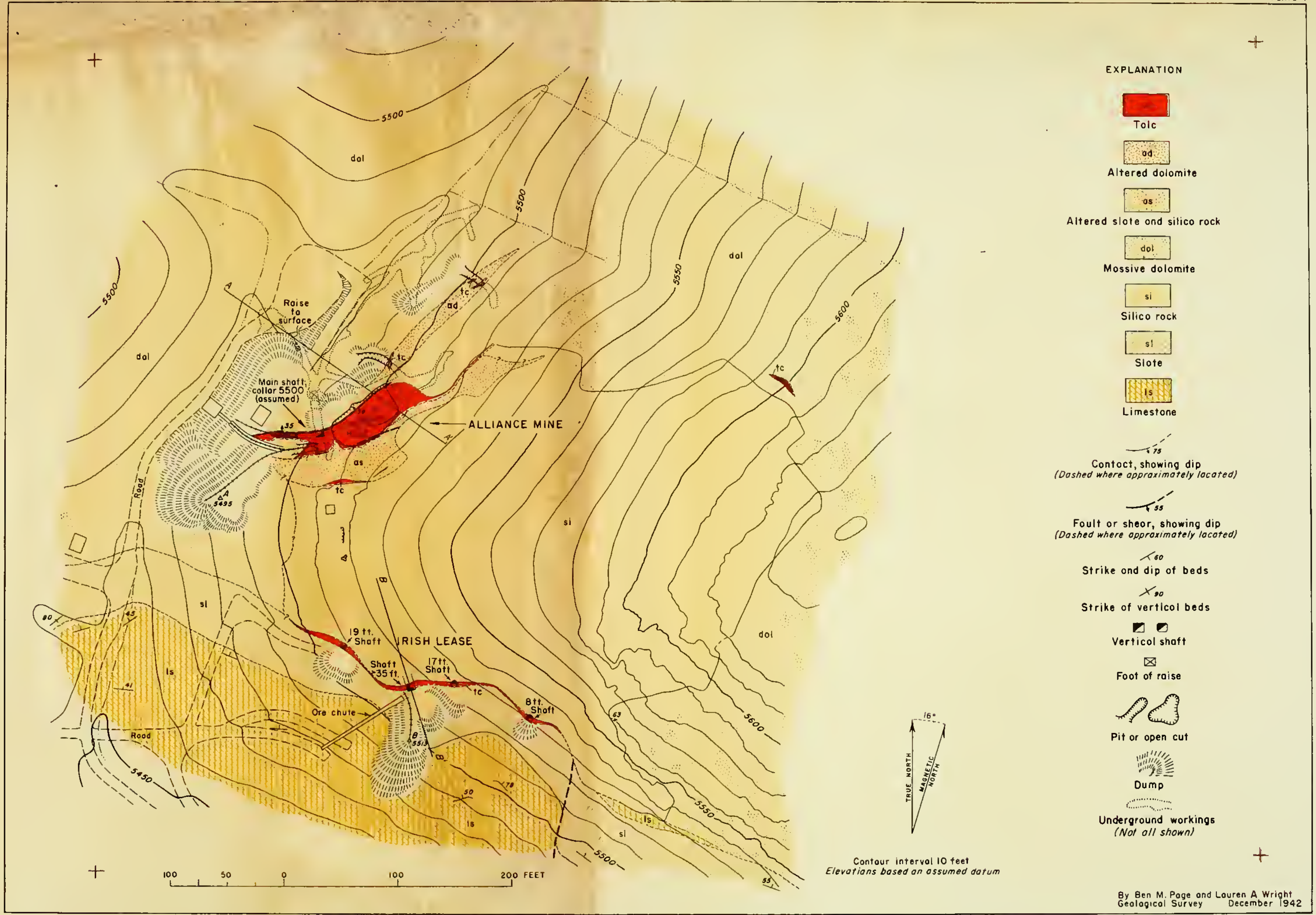
Contour interval 20 feet

Elevations referred to collar of main shaft, which is 1000.00 feet (assumed)

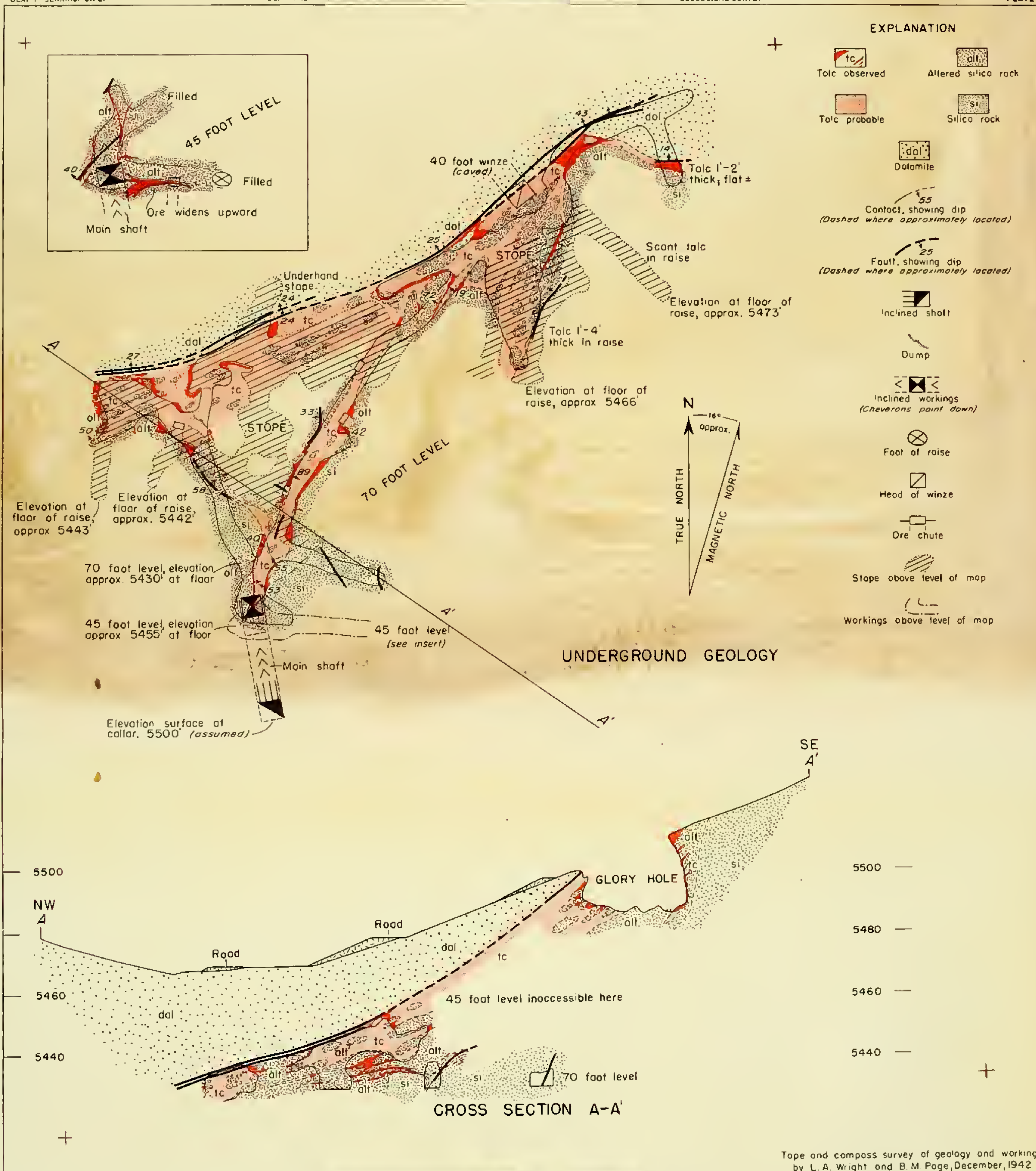
GEOLOGY OF B, C, D AND INTERMEDIATE LEVELS, TALC CITY MINE



VERTICAL SECTIONS, TALC CITY MINE



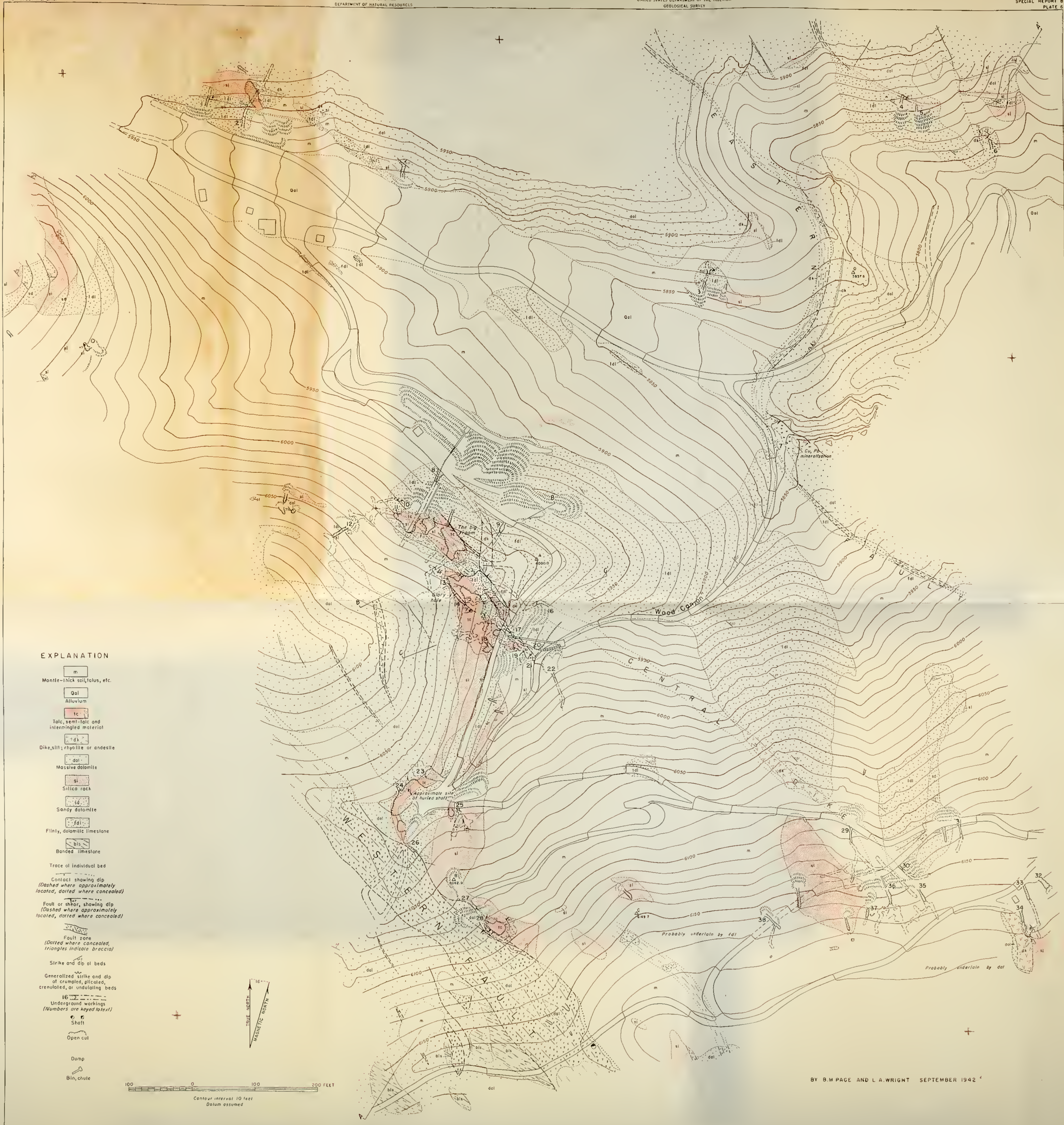
SURFACE GEOLOGY OF THE ALLIANCE TALC MINE AND IRISH LEASE, INYO COUNTY, CALIFORNIA



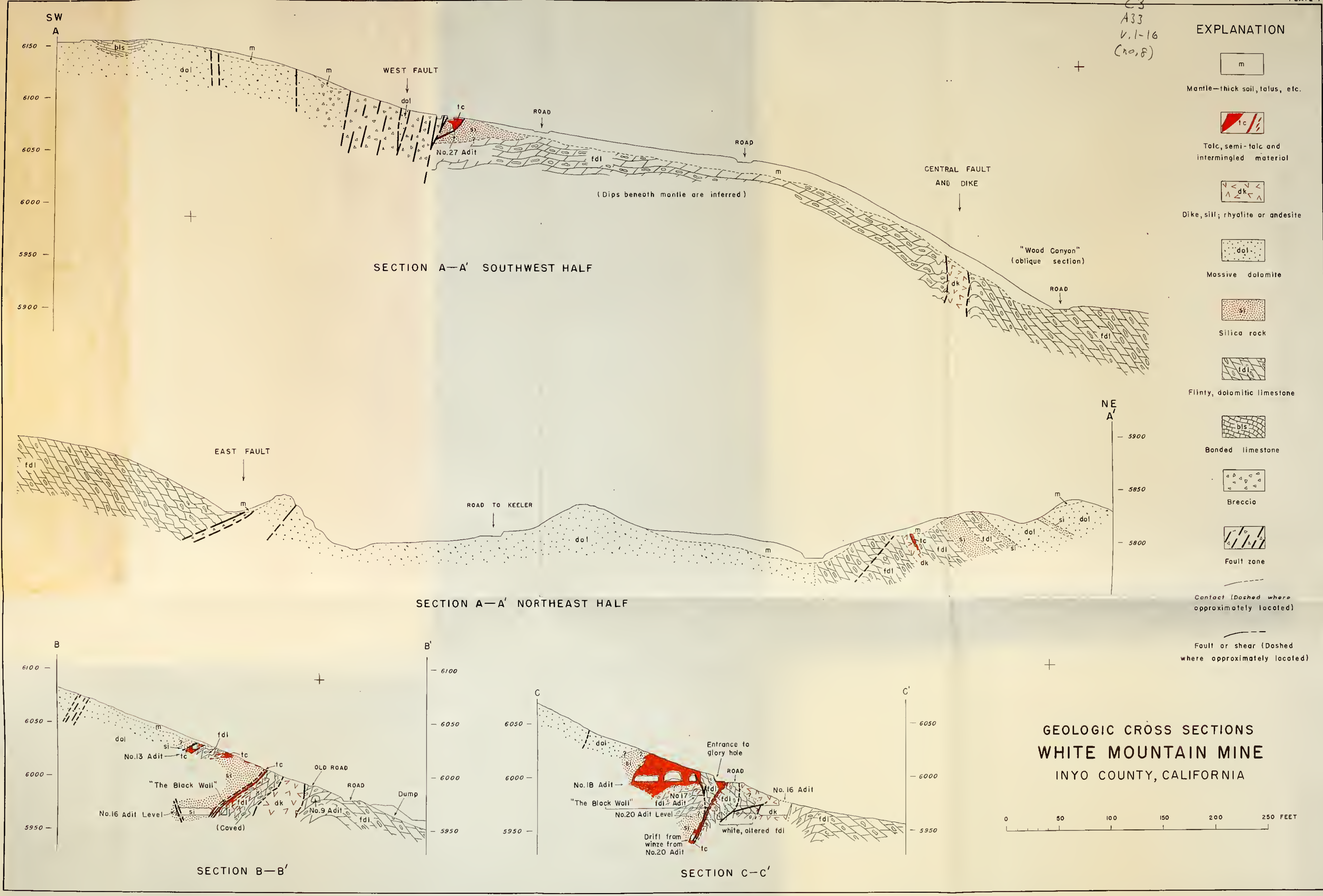
Tape and compass survey of geology and workings by L. A. Wright and B. M. Page, December, 1942

GEOLOGIC PLANS AND SECTION OF UNDERGROUND WORKINGS ALLIANCE TALC MINE, INYO COUNTY, CALIFORNIA

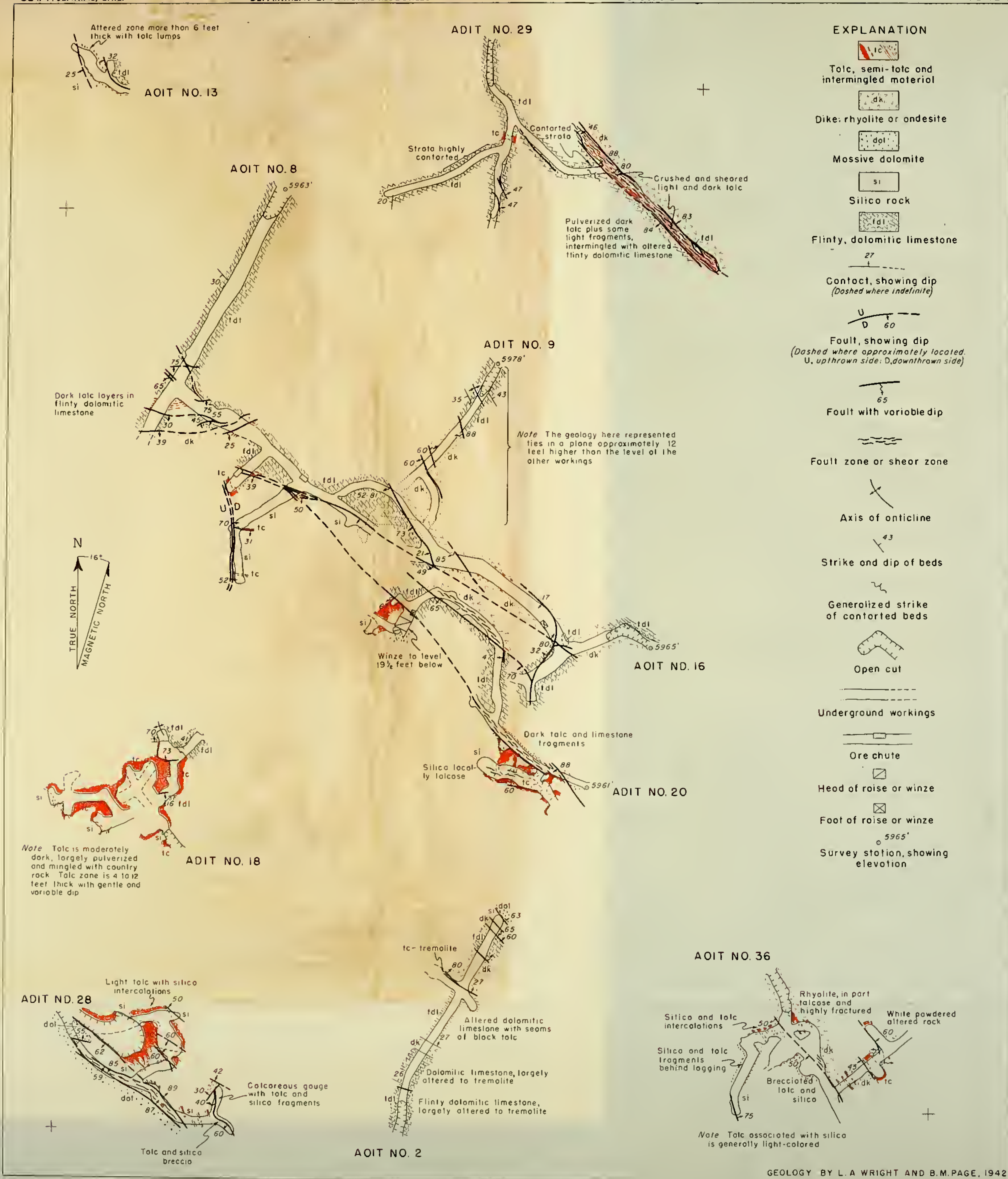
0 20 40 60 80 FEET



SURFACE GEOLOGY OF THE WHITE MOUNTAIN TALC MINE, INYO COUNTY, CALIFORNIA

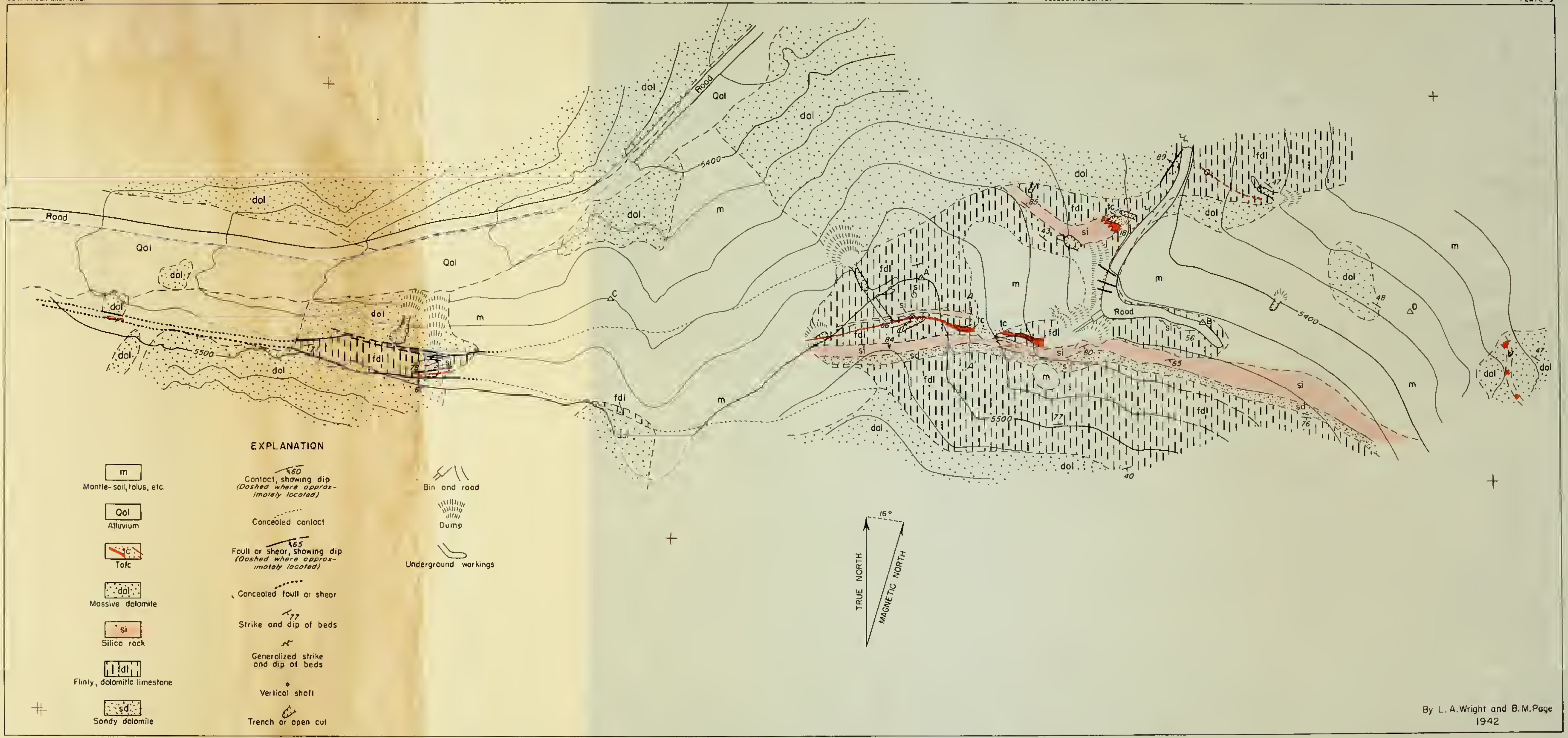


GEOLOGIC CROSS SECTIONS
WHITE MOUNTAIN MINE
INYO COUNTY, CALIFORNIA



GEOLOGIC MAP OF ADITS, WHITE MOUNTAIN MINE

0 10 50 100 FEET



GEOLOGIC MAP OF THE SOUTH DEPOSIT FLORENCE TALC MINE, INYO COUNTY, CALIFORNIA

0 100 200 300 400 500

Contour interval 20 feet

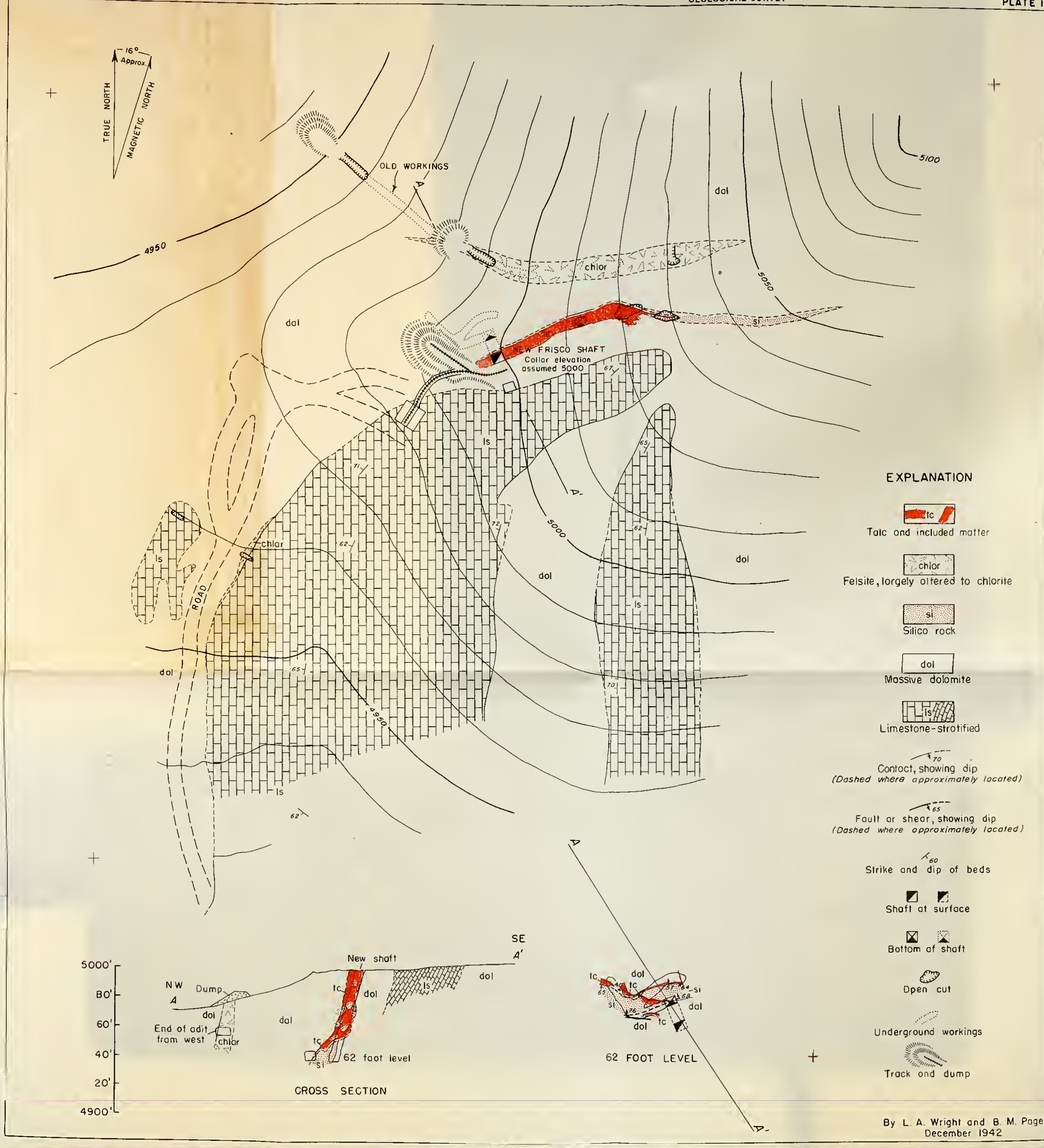
Initial elevation assumed to be 5500 feet at △A

DIVISION OF MINES
OLAF P. JENKINS, CHIEF

STATE OF CALIFORNIA
DEPARTMENT OF NATURAL RESOURCES

UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

SPECIAL REPORT 8
PLATE 10



SURFACE AND UNDERGROUND GEOLOGY OF THE FRISCO TALC MINE INYO COUNTY, CALIFORNIA

0 50 100 150 200 FEET

Contour interval 10 feet

Datum is assumed mean sea level


EXPLANATION
tl
Talus and landslide material
tc
Talc and semi-talc
gr
Granitic rocks with various inclusions
dol
Dolomitic marble
si
Silica rock
65
Contact, showing dip
(Dashed where approximately located)
Fault
(Dashed where approximately located)
50
Strike and dip of beds
Adit
Trench
Limit of quarry
Dump
Bin, chute
TRUE NORTH
MAGNETIC NORTH
16°
3400
3500
3600
3700
3800
A
GEOLOGIC MAP OF
THE WHITE EAGLE MINE
INYO COUNTY, CALIFORNIA
BY L. A. WRIGHT AND B. M. PAGE
1942
100 0 100 200 300 FEET
Contour interval 20 feet
Initial elevation assumed to be
3600 feet at Δ A